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Neighbourhood Characteristics and the Distribution of Police-reported Crime in the City of Toronto

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.	not available for any reference period
..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0s	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
p	preliminary
r	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
E	use with caution
F	too unreliable to be published

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Neighbourhood Characteristics and the Distribution of Police-reported Crime in the City of Toronto

by Mathieu Charron

1 Introduction

This research paper explores the spatial distribution of police-reported crime in the city of Toronto. The relationships between neighbourhood characteristics and crime rates are examined. The analyses are based on data from the 2006 Census and police-reported crime data from the 2006 Incident-based Uniform Crime Reporting Survey (UCR2).

This study is part of a series of spatial analyses of crime data in Canadian cities conducted by Statistics Canada. Other cities that have been analysed include: Edmonton, Halifax, Montreal, Regina, Saskatoon, Thunder Bay and Winnipeg. These studies, which have been funded by the National Crime Prevention Centre at Public Safety Canada, examine the relationships between the spatial distribution of crime and neighbourhood characteristics.

Spatial analysis of crime data provides a visual representation of areas of concentrated crime. It also helps identify neighbourhood characteristics that are related to crime levels. It can be an important tool in the development and implementation of crime reduction strategies.

The various mapping studies undertaken by the Canadian Centre for Justice Statistics support an ecological view of crime, more specifically, the social disorganization and crime opportunity theories. In keeping with this approach, the juxtaposition of the spatial distribution of police-reported crime and the environmental characteristics of neighbourhoods is examined to determine whether certain local characteristics (e.g. economic status of the residents and economic activity) are likely to foster crime. This report does not look at the individual characteristics of perpetrators or victims of crime, but rather at the characteristics of the neighbourhood environment.

In the Canadian context, the studies on neighbourhood characteristics and the distribution of crime (Fitzgerald, Wisener and Savoie 2004; Savoie, Bédard and Collins 2006; Wallace, Wisener and Collins 2006; Kitchen 2006; Andresen and Brantingham 2007; Charron 2008; Savoie 2008a; Savoie 2008b) have shown that crime is not randomly distributed within cities, but that it is concentrated in certain neighbourhoods.

Data from the Incident-based Uniform Crime Reporting Survey are reported by the police and provide a particular perspective on the nature and extent of crime, that is, they cover only crimes known to the police. Many factors can influence the reporting of offences by police services, including the public's willingness to report crimes to the police and changes in legislation, policies or enforcement practices.

The Census of Population is conducted by Statistics Canada every five years, and was last carried out in 2006. To achieve the highest degree of compatibility between crime data and neighbourhood characteristics derived from the Census, this paper draws on police and Census data from 2006.

2 Findings

Results are presented in three sections. The first includes a profile of the city of Toronto, its residential structure and the spatial organization of its economical activities, while the second section provides an account of crimes reported by the Toronto Police Service. The concentrations of violent and property crime rates are examined as well as

the corresponding neighbourhood characteristics. In the third section, spatial regressions are used to examine the relationships between the rates of 15 types of crimes and neighbourhood characteristics. This approach provides a better understanding of the contextual elements associated with local crime rates.

2.1 Portrait of the city of Toronto[1]

The Toronto urban area is the centre of the Greater Golden Horseshoe, an extensive urban zone bordering the western end of LakeOntario from Oshawa to St. Catharines–Niagara.This places Toronto at the heart of a vast metropolitan system that includes 9 of the country's 33 census metropolitan areas (CMA) and over 8,000,000 inhabitants (nearly one quarter of Canada's population). At over 5,000,000 inhabitants, Toronto was the most populous CMA in Canada in 2006.

The city of Toronto, which is the subject of this study, had a population of over 2,500,000 in 2006. It is the capital city of Ontario as well as the most populous city in Canada.Toronto is also considered to be a global city, since it represents a major economic hub in the global economy (Foreign Policy 2008).

Toronto plays a key role in international finance. In 2006, the city accounted for nearly one quarter of the country's employment in the finance and insurance industry, providing 158,205 jobs in that sector.The manufacturing, retail trade, health, and professional and technical services industries provided more than 150,000 jobs each in Toronto.

Toronto's economic activities attract a high volume of skilled workers. In 2006, 30% of Torontonians had a university degree, compared to the national average of 18%.The strong economy also accounted for an average property value ($413,574) and average individual income ($40,376) that figured significantly above the national averages ($263,369 and $35,498).

However, these indicators do not reflect the wide economic gaps among Toronto's residents. In fact, unlike the average income, the median individual income was lower in Toronto ($24,544) than elsewhere in Canada ($25,615).This difference in average and median individual incomes indicates that a small percentage of Toronto workers earn high wages, thereby increasing the average income significantly. In other words, compared with other CMAs, income inequality is considerable in the Toronto CMA (Myles et al. 2000).

In addition, part of the wealth generated in Toronto does not directly benefit the city's residents.Nearly one third of the jobs located in the city of Toronto (484,090 out of 1,514,870) were held by workers living in another municipality.This is perhaps not entirely unrelated to the fact that the unemployment rate was higher in Toronto (7.6%) than in the other municipalities of the CMA (6.1%).

Toronto's global nature is also evident in the cultural diversity of its population.In 2006, about 1 Torontonian in 5 (456,815) was a recent immigrant, having lived in the country for less than 10 years. In fact, almost one quarter of all recent immigrants in the country lived in the city of Toronto.

The mass influx of international immigrants to Toronto over the past several decades has made it one of the most cosmopolitan cities in the world.In 2006, more than half of Toronto's residents had been born outside of the country (51%) and nearly half were visible minorities (47%).These percentages are high, particularly when compared with those of the rest of the country (17% and 14% respectively).Toronto's visible minority groups each had over 10,000 members in 2006. The largest groups were the South Asians (298,370), Chinese (283,075) and Blacks (208,555).

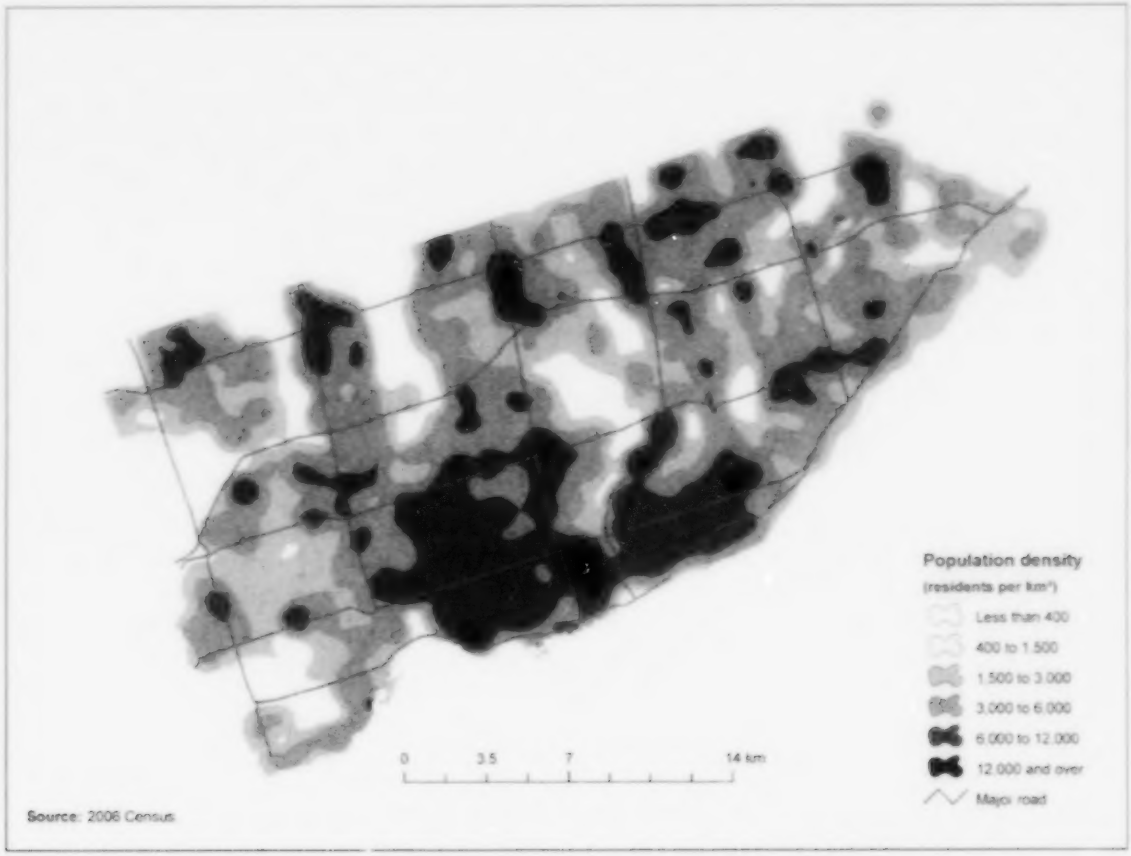
2.1.1 Geography of the city of Toronto

Toronto's residential population is not evenly distributed throughout the city (Map 1).The highest residential concentration is located close to the centre of the city, near Yonge and Bloor.Generally speaking, the further the distance from this central point, the lower the density.However, there are some high-density residential areas on

1 All data presented in this section are from the 2006 Census. See Map 7 to locate areas mentioned in the text.

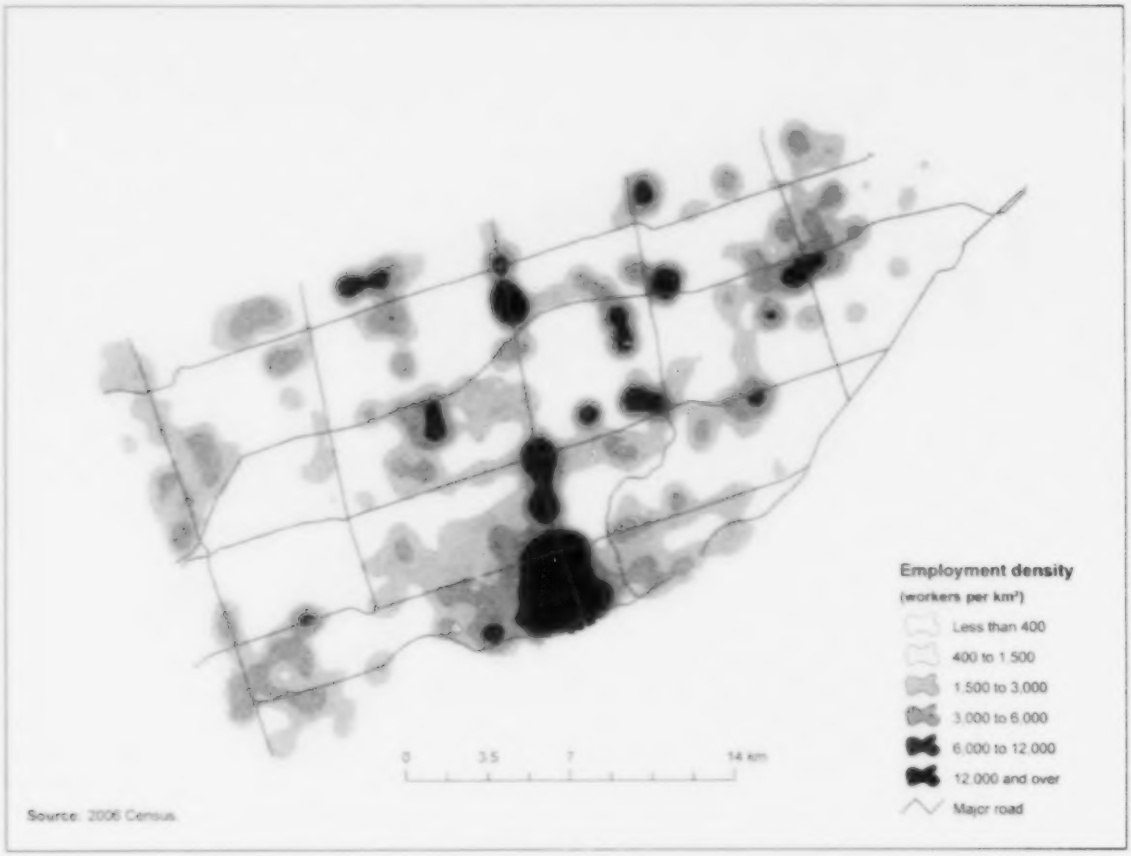
the outskirts of Toronto, particularly on Finch at Jane and Yonge and on both sides of the Don Valley Parkway. The area surrounding the Don River (East and West branches) in the city centre is a low-density zone.

Map 1
Residential population density, city of Toronto, 2006



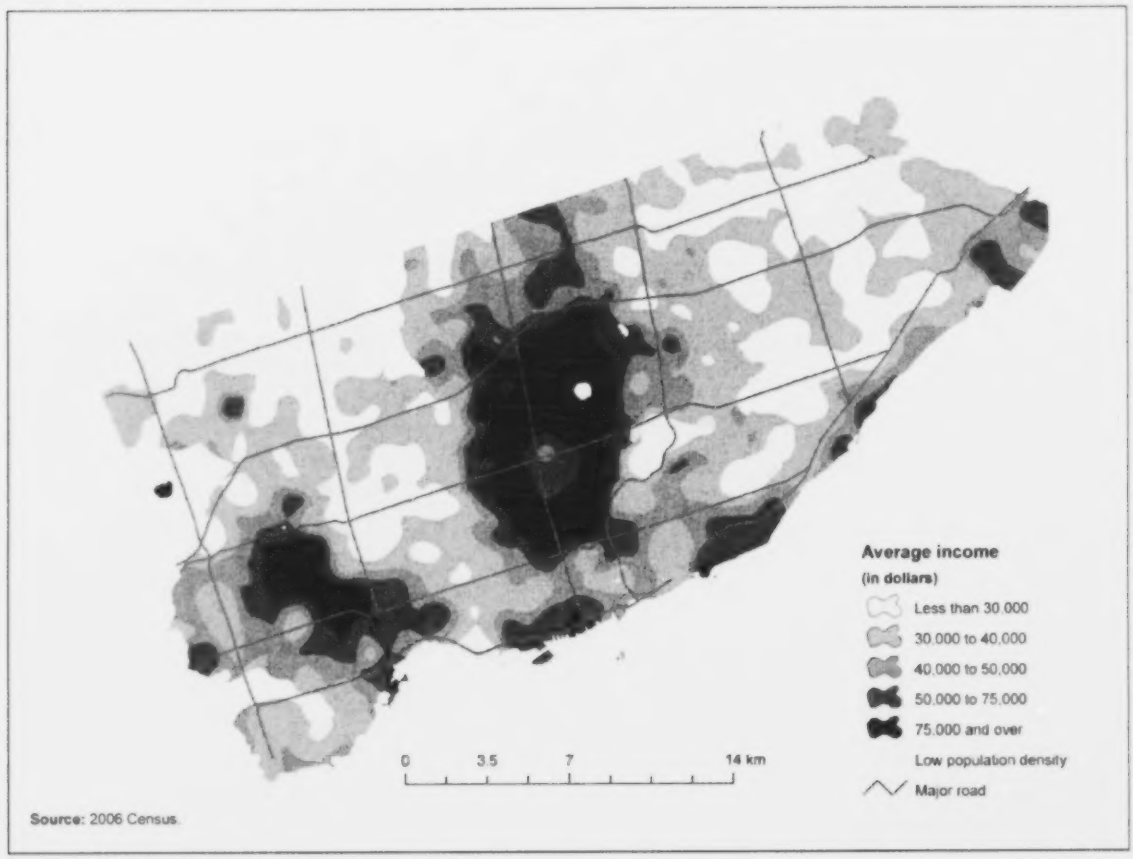
The spatial distribution of jobs also shows high concentrations within Toronto's city limits (Map 2). The highest densities are near Yonge Street at the Sheppard and Eglinton intersections, but mostly between Bloor and Front streets. More than 100,000 jobs in the finance and insurance industry were situated in this cluster in 2006. The other workplace concentrations consisted of manufacturing clusters, shopping centres or peripheral office clusters.

Map 2
Worker density, city of Toronto, 2006



The broad diversity of Toronto's population can be seen in the diversity of the city's neighbourhoods. For example, the average individual income of residents varies from one neighbourhood to another (Map 3). The neighbourhoods where the residents earn high incomes are situated along three axes: that of the shore of Lake Ontario toward the east, that of the Humber River in the west, and that of Yonge Street in the north. The neighbourhoods where the average income of residents is lower are located between the wealthier areas, along the Canadian National railway towards the northeast and the northwest.

Map 3
Average income, city of Toronto, 2006



In addition, visible minorities are proportionately more numerous on the outskirts of Toronto (Map 4).The neighbourhoods in the northeast part of the city house a large Chinese community.The Rexdale neighbourhood in the northeast and the Malvern neighbourhood in the east are home to high concentrations of South Asians, whileseveral Blacks live in the vicinity of Jane, north of Eglinton.

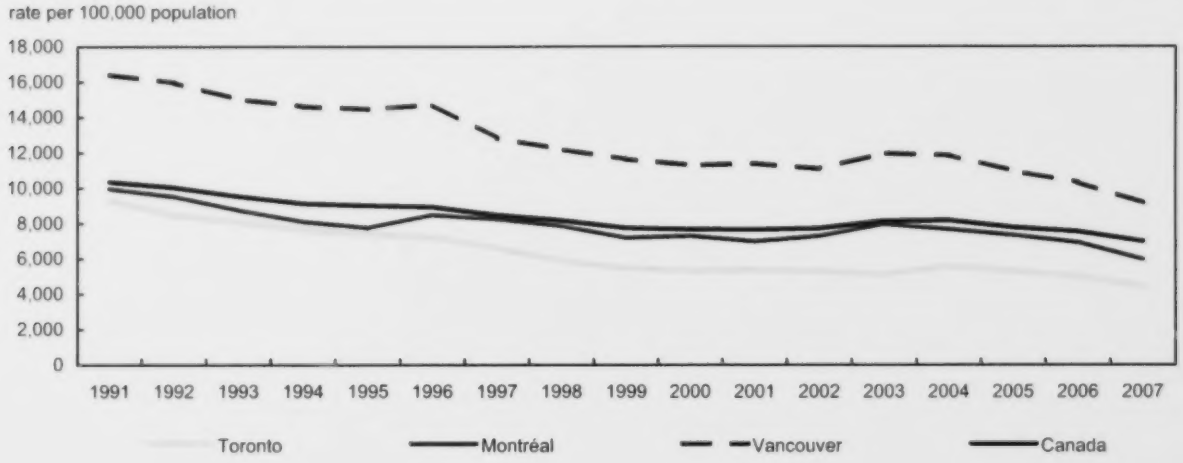
Map 4
Percentage of visible minorities, city of Toronto, 2006

Source: 2006 Census.

2.2 Police-reported crime in Toronto

Toronto is reputed to be one of the safest metropolitan areas in North America (City of Toronto 2009). Since 1991, the crime rate in the Toronto CMA has been below that of the country as a whole (Chart 1). Moreover, the rate has dropped by half since 1991, down from 9,330 to 4,461 incidents per 100,000 population. The crime rate in the Toronto CMA has remained below that of the other two most populous CMAs in the country—Montréal and Vancouver.

Chart 1
Crime rate in selected census metropolitan areas, 1991 to 2007



Note(s): Rates are based on the total number of *Criminal Code* incidents, excluding traffic offences.
Source(s): Statistics Canada, Canadian Centre for Justice Statistics, Uniform Crime Reporting Survey, 1991 to 2007.

Although Toronto has a relatively low crime rate, it is important to understand its crime patterns. With over 143,000 incidents reported in 2006 (excluding traffic offences), Toronto still had the highest number of reported offences in Canada.The number of homicide victims stood at 79 in 2005, the highest number since 1991 (86). The Toronto media coined 2005 "The Year of the Gun" because of the significant percentage of homicides committed with a firearm. This prompted the Government of Ontario to develop a gun control strategy (Ministry of the Attorney General of Ontario 2008).

The city of Toronto, which is the central municipality of the Toronto CMA and the subject of this study, is served by the Toronto Police Service. Its police-reported crime rate is higher than that of the other major police services covering the Toronto CMA (Table 1). It has been noted for several other Canadian cities that the crime rate is higher near the centre of the city (Fitzgerald et al. 2004; Wallace et al. 2006; Kitchen 2006; Charron 2008; Savoie 2008a). However, given that many non-residents come to Toronto to work or shop, the population used to calculate crime rates in Toronto may be underestimated, which has inflated the city's crime rate.

Table 1
Crime rates reported by selected police services, 2006

	Population				
	Toronto Police Service	Other police services in the Toronto census metropolitan area	Service de police de la Ville de Montréal	Vancouver Police Department	Canada
	number				
Residents	2,610,617	2,669,816	1,873,589	602,378	32,576,074
	rate per 100,000 population				
Selected incidents [1]	4,677	3,294	6,443	10,172	5,357
Violent incidents [2]	1,120	589	1,228	1,492	971
Homicide [3, 4]	2.6	1.1	2.2	2.7	1.9
Sexual assault [3, 5]	55	38	77	72	61
Assault [3]	675	360	638	867	590
Robbery [3]	178	71	219	269	85
Criminal harassment [3]	73	35	59	52	47
Uttering threats [3]	239	140	257	307	182
Property incidents [2]	3,210	2,355	4,868	7,413	3,826
Breaking and entering [3]	465	391	1,112	1,428	661
Motor vehicle theft [3]	387	132	724	626	408
Theft from a vehicle [3]	630	226	1,096	2,512	594
Shoplifting [3]	376	279	243	499	213
Other thefts [3, 6]	813	836	1,739	1,515	839
Other incidents [2, 7]	534	494	671	803	997
Drug offences [3]	210	293	183	755	252

1. For more information on selected offences, see "Data sources" in the Methodology section. The number of incidents in this table is higher than the number in the geocoded database because the location of some incidents was not available. Further, data in this table represent incident counts and not victim counts. For more information, see "Geocoding" in the Methodology section.
2. Includes the most serious violation in each incident only.
3. Includes all recorded violations in each incident.
4. Excludes attempted murder and conspiracy to commit murder.
5. Includes sexual assault levels 1, 2 and 3, as well as other sexual offences.
6. Excludes incidents of motor vehicle theft, theft from a vehicle and shoplifting.
7. Includes prostitution, as well as offensive weapon, gaming and betting and other *Criminal Code* offences.

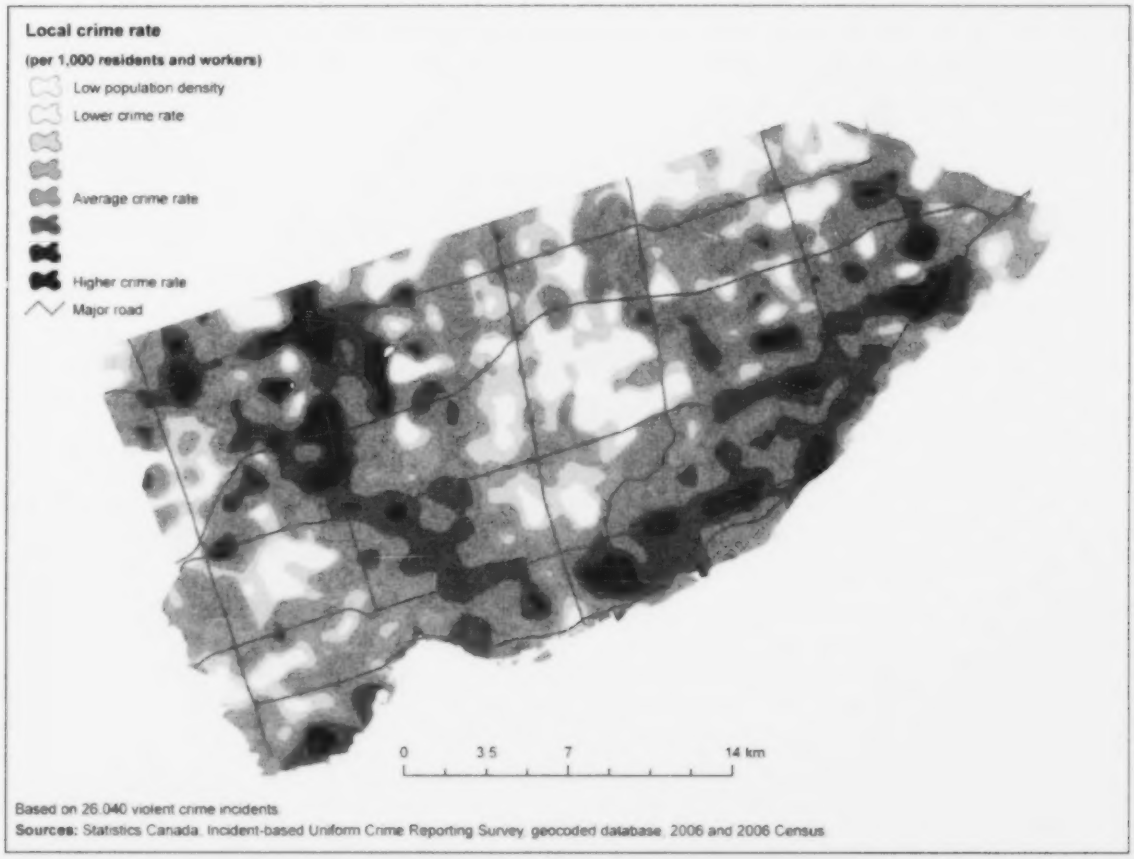
Source(s): Statistics Canada, Canadian Centre for Justice Statistics, Uniform Crime Reporting Survey, 2006.

In 2006, the crime rate in Toronto was generally lower than in two of Canada's other major central cities—Montréal and Vancouver. However, Toronto's homicide, assault and shoplifting rates were higher than Montréal's and its rate of harassment was the highest of the three central cities. Toronto's rate of property crime was below the Canadian average, while its rate of violent crime was slightly above the national average.

2.2.1 Spatial distribution of violent crime in the city of Toronto

Crimes reported to the police are not randomly distributed throughout Toronto, but are concentrated in certain areas. An examination of local crime rates (the relationship between the number of crimes and the population at a local level) shows that the rates of violent crime are higher near the downtown core and in the east and northwest areas of the city (Map 5; See "Mapping techniques" in the Methodology section for technical details.), which correspond roughly to the neighbourhoods along the Canadian National railway and to the areas where residents earn the lowest individual incomes (Map 3). There are some hot spots within these areas that have higher rates. Some of these are Danforth, downtown east side and the intersections of Lawrence and Morningside, Jane and Finch, and Jane and Eglinton.

Map 5
Local violent crime rates, city of Toronto, 2006



Based on 26,040 violent crime incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

In contrast, in the north area along Yonge Street, where residents earn a higher income, the violent crime rate is much lower than average. The business district—the Bay Street area where most of the workers in the finance and insurance industry are employed—has a violent crime rate well below the average for the city of Toronto. This differs from most of the other Canadian cities that have been the focus of studies, where the violent crime rate in the centre was high (Fitzgerald et al. 2004; Wallace et al. 2006; Kitchen 2006; Charron 2008). A similar situation was noted in Montréal, where the crime hot spots were spread out in many areas of the city (Savoie et al. 2006). The results suggest that the complex social geography of large cities like Toronto and Montréal is related to the spatial organization of crime.

Toronto's neighbourhoods, when grouped according to violent crime rates, show different characteristics (Table 2). The categories in Map 5 indicate that the rates for the crime hot spots were 18 times higher than those of the cold spots. Since these hot spots covered only a small area of the city of Toronto they only accounted for 2% of the city's crimes.

Several neighbourhood characteristics vary according to the local police-reported crime rate. Neighbourhoods with a high rate of violent crime are more densely populated and have a higher percentage of residents living in multi-unit dwellings. They also have the highest percentages of children (under the age of 15), renters, single-parent families

and visible minorities. The residents of these neighbourhoods are also less likely to have a university degree, more likely to earn a lower wage, and more likely to live in low-income households.

Table 2
Neighbourhood characteristics by violent crime rate, city of Toronto, 2006

	Lower crime			Average crime		Higher crime		City of Toronto
	rate							
Police-reported crime rate	2	3	5	9	14	23	36	9
	number							
Residents	101,030	223,570	459,970	923,150	594,880	145,730	17,210	2,465,735
Workers	170,200	273,800	393,710	423,870	175,570	39,970	4,640	1,481,975
	percent							
Percent of total crime in the city	1	5	12	35	32	12	2	100
	population per km^2							
Density (per km^2)	1,758	2,302	3,401	4,738	6,020	5,954	6,984	4,001
	percent							
Apartment buildings	19	34	42	40	37	41	56	39
Children (under 15 years old)	16	15	15	16	18	20	24	16
University graduates	57	56	51	46	40	39	35	46
	dollars							
Average employment income	82,725	66,728	54,953	37,824	32,780	30,274	24,039	44,128
	percent							
Low-income households	11	12	14	18	20	28	33	18
Single-parent families	9	9	11	14	17	22	27	14
Renters	20	30	39	48	52	61	76	46
Visible minorities	45	42	39	47	52	61	79	47

Source(s): Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

2.2.2 Spatial distribution of property crime in the city of Toronto

The property crime rate shows a significantly different distribution (Map 6) compared to violent crime rates. Property crime rates are very close to the average for a large part of the city and are distributed more evenly. However, certain hot spots are clearly evident and correspond to the city's major shopping centres. Most of the smaller shopping centres represent secondary clusters of property crime.

Map 6
Local property crime rates, city of Toronto, 2006

Based on 75,304 property crime incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

The neighbourhoods around the urban centre also show high property crime rates. These are areas of high density and significant commercial activity. Low-crime areas generally correspond to industrial areas or green spaces.

An examination of neighbourhood characteristics by police-reported crime rate supports the observations made from Map 6. It can be seen that the density of commercial activity is proportional to the local property crime rate (Table 3). As well, there are more than five workers for every resident (5:1 ratio) in the property crime hot spots, likely due to the fact that the hot spots correspond to shopping centres.

Table 3
Neighbourhood characteristics by property crime rate, city of Toronto, 2006

	Lower crime			Average crime		Higher crime		City of Toronto
	rate							
Police-reported crime rate	5	9	12	22	39	67	97	23
	number							
Residents	40,370	192,395	605,450	1,165,310	394,595	65,300	3,400	2,465,735
Workers	42,620	144,855	357,325	650,510	224,845	48,825	17,305	1,481,975
	percent							
Percent of total crime in the city	0	3	13	45	27	9	2	100
	number of workers per km^2							
Density of commercial activity	150	183	206	417	774	1,329	2,910	392
Bar density	1	2	3	6	16	17	15	6
	ratio							
Workers per resident	1.06	0.75	0.59	0.56	0.57	0.75	5.09	0.60
	percent							
Manufacturing jobs	16	16	16	13	11	8	7	14
University graduates	50	48	48	46	45	43	34	46
	dollars							
Average employment income	37,090	40,158	46,867	45,659	39,455	34,540	30,214	44,085
	percent							
Low-income households	16	17	17	17	19	23	18	18
Single-parent families	11	11	13	14	14	16	14	14
Renters	19	27	39	48	54	60	39	46
Visible minorities	69	62	48	43	47	55	50	47

Source(s): Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Property crime rates are also inversely proportional to the percentage of manufacturing jobs. It can therefore be concluded that employment clusters are only associated with this type of crime if they are related to commercial activity. In other words, clusters of manufacturing and office jobs are not linked to high property crime rates.

The commercial nature of these property crime hot spots could explain why several resident characteristics are similar to other areas in the city of Toronto. For example, in 2006 the percentage of renters (39%) was below the city average (46%), while the proportions of residents in low-income households (18%) and single-parent families (14%) were the same as the average.

Neighbourhoods where the property crime rates are close to the city average have higher average employment incomes and a percentage of visible minorities that is below the city average. Of all of the resident characteristics, only the percentage of university graduates shows a linear relationship with property crime rates. In neighbourhoods with low property crime rates, half of the residents have a university degree, whereas this percentage drops to one third in neighbourhoods with high property crime rates. High-property-crime neighbourhoods also show higher bar density than the rest of the city.

2.3 Crime rates and neighbourhood characteristics

Using the major crime categories (violent crime and property crime) analyzed so far, a summary can be drawn of the spatial organization of crime in the city of Toronto.It should be noted, however, that these are general outlines and do not cover all of the finer points of the spatial distribution of specific types of crime.Some of these details are examined in the section on the links between neighbourhood characteristics and the rates of various types of crime.

The statistical association between the rates of different types of crime and certain neighbourhood characteristics is analysed using spatial regressions (see "Multivariate regressions" in the Methodology section for technical details).Maps showing the local rates of various types of police-reported crime are included in the Appendix.

2.3.1 Neighbourhood characteristics

Other studies have shown that many neighbourhood characteristics are linked to crime (Fitzgerald et al. 2004; Savoie et al. 2006; Wallace et al. 2006; Kitchen 2006; Andresen and Brantingham 2007; Charron 2008; Savoie 2008a; Savoie 2008b).This study analyzes the statistical association between police-reported crime rates and 15 neighbourhood characteristics.All of these characteristics can be divided into five broad categories: economic characteristics of residents; cultural characteristics of residents; demographic characteristics of residents; urban characteristics of neighbourhoods and economic activities of neighbourhoods (Table 4).

Table 4
Presentation of independent variables, city of Toronto census tracts, 2006

	Type	Minimum	Maximum	Average	Standard deviation	Transformation
Socio-economic characteristics						
Access to socio-economic resources	Factor score	-2.38	2.66	0.00	1.00	None
Economic vulnerability	Factor score	-2.61	4.13	0.00	1.00	None
Ethno-cultural characteristics						
Recent immigrants	Percent	1.00	59.00	16.00	11.00	Square root
Ethno-cultural diversity	Entropy index	0.02	208.88	1.05	9.23	Logarithm
Demographic characteristics						
Children	Percent	3.00	32.00	16.00	5.00	None
Elderly people	Percent	3.00	47.00	14.00	5.00	Logarithm
Young men	Percent	0.00	15.00	6.00	2.00	Logarithm
Urban characteristics						
Centrality	Factor score	-2.80	3.05	0.00	1.00	None
Urbanization	Factor score	-2.27	2.23	0.00	1.00	None
Major repairs	Percent	0.00	52.00	6.00	4.00	Square root
Subway or train station	Dichotomous	0.00	1.00	0.29	0.46	None
Economic activity						
Commercial activity	Number	0	10,192	466	1,035	Logarithm
Manufacturing jobs	Number	0	16,455	385	1,213	Logarithm
Office jobs	Number	0	95,144	982	4,626	Logarithm
Bars	Number	0	615	7	30	Logarithm

Note(s): Based on 524 census tracts.
Source(s): Statistics Canada, 2006 Census.

Economic characteristics of neighbourhood residents

It is generally accepted that the lack of access to socio-economic resources impedes the establishment of social control of crime by the resident population (Forrest and Kearns 2001; Sampson et al. 2002). In addition, the lack of integration into the economic system and the resulting stigmatization compromise adherence to the behavioural norms held by society in general (Massey 1996; Body-Gendrot 2001; Forrest and Kearns 2001; Bauder 2002; Sampson et al. 2002).

Access to socio-economic resources is measured in part by a number of census variables, each of these covering a specific aspect of disadvantage. For example, the level of education provides a partial, indirect measure of an

individual's ability to find skilled employment, while average income gives a partial measure of short term access to financial resources. There are some considerations to note when using these variables. For example, financial resources also depend on wealth and savings, and annual incomes are not guaranteed over the long term.

Because of the complexity of measuring socio-economic resources, several variables can cover certain aspects of it. Since many of these variables are strongly correlated, they cannot all be integrated into the multivariate analyses. To resolve these problems, a factor analysis was used to derive two indicators of access to socio-economic resources from the relevant census variables (see "Variables" in the Methodology section for technical details). Factor analyses enable us to identify the major patterns in a group of variables and, in this case, to measure the extent of the socio-economic disadvantage based on a group of variables.

The first indicator (**access to socio-economic resources**) derived from the factor analysis covers the greater part of socio-economic resources. The percentage of residents with a university degree, the percentage of residents without a high school diploma, and the proportion of total income represented by government transfers contribute significantly to the value of this indicator. The average property value, the average personal income and the percentage of residents in a lone-parent family are the other major contributors to this indicator.Measured in this way, access to socio-economic resources results in a sectional spatial configuration. The communities in the north and east areas have greater access to socio-economic resources than do those in the northeast and northwest areas.

The second indicator (**socio-economic vulnerability**) derived from the factor analysis represents a different aspect of socio-economic resources. The variables that contribute most are the unemployment rate and the percentage of residents living in a low-income household. The communities with the greatest socio-economic vulnerability are spread throughout the city with some of them corresponding to public housing areas.

Cultural characteristics of neighbourhood residents

Several theories suggest that the ethno-cultural dimension of neighbourhoods can be associated with local crime rates. In this study, three variables are used to represent this dimension: the proportion of **visible minorities,** the proportion of **recent immigrants** and **ethno-cultural diversity.**

A number of studies have focussed on the relationship between race and crime, particularly in the United States (Felson et al. 2008). It is generally accepted that this association is particularly complex. In the United States, a number of theories have been proposed to explain this association, most referring to the historical effects of long years of discrimination and segregation (Felson et al. 2008). In Canada, several studies have shown that the association between the percentage of members of a visible minority or Aboriginal group and crime is explained essentially by other characteristics of those neighbourhoods (Fitzgerald et al. 2004; Savoie et al. 2006; Wallace et al. 2006; Charron 2008; Fitzgerald and Carrington 2008; Savoie 2008a; Savoie 2008b).

Fewer studies have been done on the link between immigration and crime than on the relationship between visible minority status (race) and crime (Martinez 2006). Most empirical research shows that if there is a relationship between immigration and crime, it is an inverse one, that is, increased immigration equates to less crime (Martinez 2006). This can partially be explained by the fact that recent immigrants tend to have a much higher level of education than non-immigrants (Galarneau and Morissette 2008). In this study, immigration is measured as the proportion of neighbourhood residents who immigrated to Canada between 1997 and 2006.

According to the foundational work of Shaw and MacKay (1942), a neighbourhood's cultural heterogeneity is associated with crime to the extent that it is accompanied by diversity in normative and linguistic terms that might inhibit community cohesion (Elliot et al. 1996). In this study, ethno-cultural diversity is measured using an entropy index for visible minority groups. The entropy index measures the diversity of groups in a census tract. If several groups are present in large numbers, the index value is high (see "Variables" in the Methodology section).

Demographic characteristics of neighbourhood residents

At the individual level, the relationship between age and police-reported crime has been clearly shown (Piquero et al 2003; Matarazzo 2005). In the incidents that were geocoded for this study, children (under 15 years of age) represented only 6.2% of accused and 10.1% of victims, while they made up 16.4% of the city of Toronto's total population. The representation of people aged 65 and older in the data on crimes reported to police was even

lower. This group made up only 1.7% of accused and 2.4% of victims, although it accounted for 14.1% of the total population. In contrast, young men aged 20 to 29 accounted for 20.8% of accused and 14.6% of victims, while only representing 7.0% of the total population.

Analyses of residential segregation show that neighbourhoods are distinguished by the age of their residents (Davies and Murdie 1993). It is therefore important to verify if the demographic structure of neighbourhoods is related to crime hot spots. Men are generally more likely than women to be involved in criminal incidents, whether as victims or accused. However, since all neighbourhoods usually have similar proportions of men and women among their residents, sex is not strongly associated with crime at the neighbourhood level.

In the city of Toronto, areas where **children** (under 15 years of age) are overrepresented are spread throughout the city in neighbourhoods such as Jane-Finch and RegentPark. Neighbourhoods where **elderly people** (65 and older) are overrepresented are also widely dispersed, but are in different locations, such as Westmount. As for **young men** (aged 20 to 29), they are overrepresented in the downtown area and around YorkUniversity.

Urban characteristics of neighbourhoods

Since the pioneering work associated with the Chicago school (Simmel 1903; Park and Burgess 1925; Shaw and McKay 1942), the urban nature of neighbourhoods has been linked to a particular way of life. Residents of inner city neighbourhoods live in a busy environment where there is a high concentration of individuals who are unknown to one another. Such conditions probably influence social relationships, which become more anonymous and individualistic. By impeding the development of strong social networks, of social cohesion[2] in the neighbourhood (Sampson and Morenoff, 2004) and of attachment to one's neighbourhood, those conditions might foster crime (Pain 2000; Brown et al. 2004).

As mentioned, the city of Toronto's urban structure is complex; it is not simply characterized by a decreasing density from downtown to the suburbs (Map 1 and Map 2). To take this complexity into account, two urban characteristic indicators have been derived from a factor analysis (see "Variables" in the Methodology section): **centrality** and **urbanization.**

Centrality is mainly characterized by ageing buildings and distance to downtown (corner of Queen and Yonge streets). Thus, the degree of centrality decreases gradually from downtown towards the outskirts.

Neighbourhoods characterized by a high level of urbanization are dense, have many apartment buildings but few single-detached houses, and include dwellings with few rooms. Residents of those neighbourhoods are more likely to be renters and to have moved during the last year, but less likely to have been in the same place for five years or to drive to work. Highly urban neighbourhoods are found in various areas including downtown, York University and Flemingdon Park.

Thus, urbanization and centrality represent different realities in Toronto. Some neighbourhoods (such as Rosedale) might be central but not very urban, while others might be on the outskirts and urban (such as Jane-Finch).

According to the broken window theory, degradation of the physical environment promotes crime (Kelling and Coles 1998). The presence of graffiti, garbage and run-down buildings might engender a sense of not caring, thus creating an environment that favours crime (Brown et al. 2004). No variable measures degradation of the physical environment directly at the census tract level. In this study, the proportion of dwellings requiring **major repairs** is used as an indirect measure. Such dwellings are overrepresented in the areas located immediately to the northwest and the east of downtown, as well as in certain other locations.

As in many other large urban areas, in Toronto, the public transit system greatly influences travel. The 2006 Census indicated that over a third (34%) of Torontonians use public transit to get to work. Thus large numbers of travelers flow through the many subway and train stations throughout the city. To determine the possible impact of these transit areas on crime, the presence of a **subway or train station** was added as a dichotomous variable in the multivariate models.

2. The concept of social cohesion is used regularly in studies on how society works. While definitions may vary, strong social cohesion stems from a situation where the members of a group participate in and contribute to social well-being, and where conflicts are rare. The concept of social cohesion is complex and can include many components, such as common values, group solidarity, high social capital, a sense of belonging and a territorial identity (Kearns and Forrest 2000).

Economic activities of neighbourhoods

According to the crime opportunity theory (Cohen and Felson 1979), the concentration of business activity might favour crime since it brings many opportunities for crime together in a single location. In this study, **commercial activity** is measured by the number of retail trade, accommodation and food service workers. In Toronto, business activity is concentrated in a few clusters, including downtown and major shopping centers.

Other employment clusters characterize Toronto's spatial structure. To determine the impact of a neighbourhood's economic activity on crime, **manufacturing jobs** and **office jobs** are also taken into consideration.

The role of bars in criminal activity has been examined in a number of studies. These were based on the assumption that the presence of such establishments might influence social standards in the neighbourhood (allowing more tolerance) or might attract drinkers to a setting that favours violent crime (Treno et al. 2007). In this paper, **bars** are measured by the number of workers in beverage outlets in the census tract.

2.3.2 Neighbourhood characteristics and local crime rates: Results

The following multiple regression results show the differences in local rates of police-reported crime and how they relate to the neighbourhood characteristics described above.[3] The results identify the neighbourhood characteristics that are more closely linked to crime rates after controlling for other characteristics.

Many regression models were used—one for each of the 15 types of crimes analyzed. They are presented in five tables in order to allow comparisons of the impact of neighbourhood characteristics on various types of crimes. The results are examined after the tables are presented.

It must be noted that the measure of crime used in this document (police-reported crime) relies on statistical data from police forces, which include only crimes reported to them that have been substantiated by a police investigation. Many factors can influence the police-reported crime rate, including the willingness of the public to report crimes to the police and changes in legislation, policies or enforcement practices.

Economic activities of neighbourhoods violent crime and property crime

Map 5 and Map 6 show that the spatial organization of violent crime rates differs from that of property crime rates. The spatial regression model results (see "Multivariate regressions" in the Methodology section) below allow a better understanding of the differences (Table 5 and Table 6).

3 The 'visible minorities' variable was strongly associated with other variables, particularly the 'recent immigrants' variable and the socio-economic characteristics of neighbourhood residents. Since these strong associations posed a multicollinearity problem, the variable was removed from the regression models. The examination of data suggests that the visible minorities variable did not show strong statistical associations with crime rates.

Table 5
Regression models (indicators) for violent and property crime rates, city of Toronto census tracts, 2006

	Violent crime	Property crime
	number	
Number of incidents	26,040	75,304
	percent	
Explanatory power [1]	63.9	47.7
	regression coefficients (b)	
Socio-economic characteristics		
Access to socio-economic resources	-0.397***	-0.201***
Economic vulnerability	0.178**	...
Ethno-cultural characteristics		
Recent immigrants	-0.284***	-0.146**
Ethno-cultural diversity	...	...
Demographic characteristics		
Children	...	...
Elderly people	-0.143***	-0.167***
Young men	...	...
Urban characteristics		
Centrality	...	0.245***
Urbanization	0.165***	0.122*
Major repairs	0.173***	...
Subway or train station	0.154*	0.193*
Economic activity		
Commercial activity	0.198***	0.501***
Manufacturing jobs	-0.117**	-0.108*
Office jobs	-0.171**	-0.242***
Bars	...	...
Spatial lag [1]	0.391***	0.304***

... not applicable (variables excluded from the model because they are not significant [p<0.05])
* Significantly associated with dependent variable p<0.05
** Significantly associated with dependent variable p<0.01
*** Significantly associated with dependent variable p<0.001
1. Data represent the squared correlation coefficients between observed and predicted values, a measure that is related to the coefficient of determination (R^2). See "Spatial autocorrelation and regression" in the Methodology section for more information on autoregressive spatial models.

Note(s): Based on 524 census tracts. Regression models include intercept. Population at risk includes residents and workers.
Source(s): Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Table 6
Regression models (all variables) for violent and property crime rates, city of Toronto census tracts, 2006

	Violent crime	Property crime
	number	
Number of incidents	26,040	75,304
	percent	
Explanatory power [1]	66.3	51.0
	regression coefficients (b)	
Socio-economic characteristics		
University graduates	-0.162***	...
No high school diploma	...	0.165**
Single-parent families	0.193***	0.121*
Low-income households	0.125*	...
Ethno-cultural characteristics		
Recent immigrants	-0.205***	-0.200***
Ethno-cultural diversity	0.069*	...
Demographic characteristics		
Children	...	...
Elderly people	-0.109***	-0.108***
Young men	...	...
Urban characteristics		
Single-detached houses	-0.089*	...
Renters	0.153***	0.121*
Did not move	...	-0.177**
Age of buildings	...	0.187***
Major repairs	0.158***	...
Subway or train station	0.160**	0.203**
Economic activity		
Commercial activity	0.203***	0.471***
Manufacturing jobs	-0.113**	-0.118**
Office jobs	-0.203***	-0.224***
Bars	0.0763*	0.080*
Spatial lag [1]	0.373***	0.304***

... not applicable (variables excluded from the model because they are not significant [p<0.05])
* Significantly associated with dependent variable p<0.05
** Significantly associated with dependent variable p<0.01
*** Significantly associated with dependent variable p<0.001
1. Data represent the squared correlation coefficients between observed and predicted values, a measure that is related to the coefficient of determination (R^2). See "Spatial autocorrelation and regression" in the Methodology section for more information on autoregressive spatial models.

Note(s): Based on 524 census tracts. Regression models include intercept. Population at risk includes residents and workers.
Source(s): Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

The statistical association between violent and property crime rates and various neighbourhood characteristics is analyzed based on two sets of independent variables.

In the first set (indicators, Table 5), the socio-economic characteristics of residents and the urban characteristics of neighbourhoods are represented by the variables described above, access to socio-economic resources, economic vulnerability, centrality and urbanization. These variables are indicators derived from factor analyses and are more closely related to the major theories on links between crime and neighbourhood characteristics.

The second set of variables (all variables, Table 6) does not include indicators that represent the concepts in environmental criminology theories but rather the set of 19 variables that make up the four indicators (see "Factor analysis" in the Methodology section). These models thus include 31 independent variables. Similar to those used in earlier studies (Savoie et al. 2006; Wallace et al. 2006; Savoie 2008a), they are included for purposes of comparison with the results obtained for those cities.

The two models that include socio-economic and urban characteristic indicators (Table 5) account for half of the variation in the police-reported crime rates. However, they display different structures. For example, dwellings requiring major repairs and economic vulnerability are associated with violent crime, while centrality is associated only with property crime.

Several neighbourhood characteristics are associated with the two types of crime but in different proportions. For example, commercial activity is the characteristic most strongly associated with property crime rates, while access to socio-economic resources is more closely related to violent crime rates. Also, urbanization is more strongly associated with violent crime than with property crime.

Finally, the two categories of crime are inversely proportional to the number of manufacturing jobs and office jobs, but their rates are higher in neighbourhoods where subways or train stations are located.

The two types of regression models (with socio-economic and urban characteristic indicators or with the set of all variables) produce comparable results. In fact, it seems that certain variables explain crime rates about as well as the indicators: the proportion of lone-parent families for access to socio-economic resources, and the age of buildings for centrality.

The exact impact of each neighbourhood characteristic may, however, vary according to the set of independent variables. For example, the 'bars' variable is significant only in the models that include all variables. Despite small differences such as these, the results that were obtained through the models using indicators and the models using all independent variables were similar.

Various types of violent crime

Access to socio-economic resources is closely related to all types of violent crime, particularly uttering threats and major assault (Table 7). The other neighbourhood characteristics, however, differ in their association with the various types of police-reported violent crime. For example, economic vulnerability is associated with sexual assault, uttering threats, major assault and robbery, but not with harassment and common assault.

Table 7
Regression models for selected violent crime rates, city of Toronto census tracts, 2006

	Sexual assault	Criminal harassment	Uttering threats	Common assault	Major assault	Robbery
	number					
Number of incidents	1,137	1,645	5,468	11,680	3,926	4,181
	percent					
Explanatory power [1]	24.6	11.6	52.8	55.8	54.2	40.4
	regression coefficients (b)					
Socio-economic characteristics						
Access to socio-economic resources	-0.311***	-0.159**	-0.480***	-0.233***	-0.458***	-0.3568***
Economic vulnerability	0.175**	...	0.186***	...	0.205***	0.281***
Ethno-cultural characteristics						
Recent immigrants	-0.422***	-0.213***	-0.282***	-0.217***	-0.315***	-0.240***
Ethno-cultural diversity	0.135**	...	...	...	...	...
Demographic characteristics						
Children	...	0.162**	...	0.155***	...	...
Elderly people	-0.118**	...	-0.112**	...	-0.139***	-0.140***
Young men	...	0.150**	...	0.122***	...	...
Urban characteristics						
Centrality	...	...	...	...	...	...
Urbanization	0.261***	0.139*	0.167***	0.299***	0.158***	...
Major repairs	...	0.155*	0.108**	0.206***	0.132***	0.089*
Subway or train station	0.252**	...	...	...	...	0.274***
Economic activity						
Commercial activity	...	...	...	0.135***	0.111**	0.291***
Manufacturing jobs	...	...	-0.063*	...	-0.111**	-0.142*
Office jobs	-0.178***	...	...	-0.200***	...	-0.203*
Bars	...	...	...	...	...	...
Spatial lag [1]	...	...	0.327***	0.400***	0.351***	0.295***

... not applicable (variables excluded from the model because they are not significant [p<0.05])
* Significantly associated with dependent variable p<0.05
** Significantly associated with dependent variable p<0.01
*** Significantly associated with dependent variable p<0.001
1. For the sexual assault and criminal harassment rate models, data represent the coefficients of determination (R^2). For the other models, which are autoregressive, they are the squared correlation coefficients between observed and predicted values. See "Spatial autocorrelation and regression" in the Methodology section for more information on autoregressive spatial models.
Note(s): Based on 524 census tracts. Regression models include intercept. Population at risk includes residents and workers.
Source(s): Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

The percentage of recent immigrants is inversely proportional to all types of violent crime. It should also be noted that ethno-cultural diversity is associated only with sexual assault.

As for demographic characteristics, rates of harassment and common assault increase with the proportion of children (under 15) and of young men (aged 20 to 29). Rates of sexual assaults, threats, major assaults and robberies decrease as the proportion of people aged 65 and older increases.

All rates (with the exception of the robbery rate) are higher in more urban neighbourhoods, while none of the rates are higher in more central neighbourhoods. All rates (with the exception of the sexual assault rate) are higher in neighbourhoods with a high proportion of dwellings requiring major repairs, while the rates of sexual assaults and robberies are higher in neighbourhoods where there is a subway or train station.

Finally, assault and robbery rates increase with commercial activity. Rates of sexual assault, common assault and robbery are lower in areas where there are high concentrations of office workers.

Various types of theft

Unlike the various types of violent crime, which are all more or less associated with the same neighbourhood characteristics, the rates of various types of police-reported theft show very different spatial structures (Table 8).

Table 8
Regression models for rates of selected theft offences, city of Toronto census tracts, 2006

	Shoplifting	Theft from a motor vehicle	Motor vehicle theft	Other thefts
	number			
Number of incidents	9,214	15,731	5,804	19,972
	percent			
Explanatory power [1]	20.1	27.5	33.8	56.6
	regression coefficients (b)			
Socio-economic characteristics				
Access to socio-economic resources	-0.187***	-0.098*	-0.192***	...
Economic vulnerability	...	...	...	...
Ethno-cultural characteristics				
Recent immigrants	...	...	...	-0.319***
Ethno-cultural diversity	...	...	...	0.083**
Demographic characteristics				
Children	...	...	0.348***	-0.113**
Elderly people	...	-0.133***	...	-0.071*
Young men	...	...	0.135**	...
Urban characteristics				
Centrality	...	0.263***	...	...
Urbanization	...	0.097*	...	0.143**
Major repairs	...	...	0.085*	0.194***
Subway or train station	...	...	0.221**	...
Economic activity				
Commercial activity	0.632***	...	0.116*	0.521***
Manufacturing jobs	-0.268***	...	0.092*	...
Office jobs	...	...	...	-0.236***
Bars	-0.131**	0.099*	...	...
Spatial lag [1]	...	0.382***	0.368***	0.379***

... not applicable (variables excluded from the model because they are not significant [p<0.05])
* Significantly associated with dependent variable p<0.05
** Significantly associated with dependent variable p<0.01
*** Significantly associated with dependent variable p<0.001
1. For the shoplifting rate model, data represent the coefficient of determination (R^2). For the other models, which are autoregressive, they are the squared correlation coefficients between observed and predicted values. See "Spatial autocorrelation and regression" in the Methodology section for more information on autoregressive spatial models.

Note(s): Based on 524 census tracts. Regression models include intercept. Population at risk includes residents and workers.
Source(s): Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Shoplifting is strongly associated with the neighbourhood's economic activity. Its rates are higher where commercial activity is high. However, shoplifting rates are lower in areas with high concentrations of manufacturing jobs, in neighbourhoods where there is a higher concentration of bars, and where residents have greater access to socio-economic resources.

Rates of theft from a motor vehicle are higher in neighbourhoods with a greater number of bars and in central and urban neighbourhoods. These rates are lower in neighbourhoods with higher proportions of older residents (65 and over).

Motor vehicle theft rates are higher in neighbourhoods with higher proportions of children (under 15) and young men aged 20 to 29. They are also higher in neighbourhoods where access to socio-economic resources is limited or where there is a subway or train station, as well as in clusters of commercial and manufacturing activity.

Finally, other thefts vary according to several neighbourhood characteristics, mainly commercial activity and the proportion of recent immigrants.

Breaking and entering, mischief and drug offences

The spatial structure of breaking and entering varies essentially with urban and economic activity characteristics. More specifically, results show that breaking and entering is relatively more frequent in central neighbourhoods, with high commercial activity, but less so in areas with high numbers of office jobs (Table 9).

Table 9
Regression models for selected crime rates, city of Toronto census tracts, 2006

	Breaking and entering	Mischief	Drug offences
	number		
Number of incidents	11,628	14,389	2,934
	percent		
Explanatory power [1]	26.4	47.5	45.2
	regression coefficients (b)		
Socio-economic characteristics			
Access to socio-economic resources	...	-0.220***	-0.461***
Economic vulnerability	...	...	0.194***
Ethno-cultural characteristics			
Recent immigrants	...	-0.223***	-0.360***
Ethno-cultural diversity	...	...	0.138*
Demographic characteristics			
Children	...	...	...
Elderly people	-0.089*	-0.188***	-0.148***
Young men	...	...	0.097*
Urban characteristics			
Centrality	0.460***	0.188***	0.262***
Urbanization	...	...	0.190***
Major repairs	...	0.150**	...
Subway or train station	...	0.243**	-0.173*
Economic activity			
Commercial activity	0.279***	0.127**	0.240***
Manufacturing jobs	...	-0.126**	...
Office jobs	-0.359***	-0.133*	-0.133*
Bars	...	...	...
Spatial lag [1]	...	0.386***	...

... not applicable (variables excluded from the model because they are not significant [p<0.05])
* Significantly associated with dependent variable p<0.05
** Significantly associated with dependent variable p<0.01
*** Significantly associated with dependent variable p<0.001
1. For the breaking and entering and drug offence rate models, data represent the coefficient of determination (R^2). For the other models, which are autoregressive, they are the squared correlation coefficients between observed and predicted values. See "Spatial autocorrelation and regression" in the Methodology section for more information on autoregressive spatial models.

Note(s): Based on 524 census tracts. Regression models include intercept. Population at risk includes residents and workers.
Source(s): Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Mischief and drug offences are more dependant on access to socio-economic resources, a low proportion of recent immigrants and elderly people, centrality and commercial activity. Mischief also occurs more frequently where there are dwellings requiring major repairs, while drug offences are more common in more urban and ethno-culturally diverse neighbourhoods.

2.3.3 Neighbourhood characteristics and local crime rates: Analysis of results

The results presented above are interpreted and summarized below in five sections, one for each category of neighbourhood characteristics.

Socio-economic characteristics of neighbourhood residents

Generally speaking, residents' socio-economic characteristics are more closely associated with violent crime rates, however, access to socio-economic resources is more strongly linked to crime rates than economic vulnerability.

Uttering threats, major assault and drug offences showed the closest association with access to socio-economic resources. Other strong links were noted for mischief, motor vehicle theft, robbery, sexual assault and common assault. Only other thefts (which exclude shoplifting, theft from a motor vehicle and motor vehicle theft) and breaking and entering were not significantly associated with access to socio-economic resources.

Economic vulnerability was associated with generally serious violent crimes: robbery, major assault, sexual assault and uttering threats. It was not related to common assault, harassment or any type of property crime.

These findings tend to support the results from studies of other Canadian cities (Fitzgerald et al. 2004; Savoie et al. 2006; Wallace et al. 2006; Kitchen 2006; Andresen and Brantingham 2007; Charron 2008; Savoie 2008a; Savoie 2008b). Access to socio-economic resources seems to be one of the neighbourhood characteristics most closely associated with crime rates. In Toronto, it is more closely linked to violent crime than property crime. The nature of the data used in this report does not allow us to directly link crime rates and the socio-economic characteristics of neighbourhood residents. However, the results do not contradict theories that social cohesion, which would be measured indirectly by access to socio-economic resources, favours social control of crime by the local community (Forrest and Kearns 2001; Sampson et al. 2002).

Moreover, results suggest that the economic vulnerability of a neighbourhood's residents, combined with limited access to socio-economic resources, can create a setting that is conducive to the perpetration of violent crimes such as serious assault, robbery and sexual assault. These results are consistent with theories that failure to integrate into the economic system leads to a lack of respect for the standards of behaviour endorsed by society in general (Massey 1996; Body-Gendrot 2001; Forrest and Kearns 2001; Bauder 2002; Sampson et al. 2002).

Cultural characteristics of neighbourhood residents

On the whole, it seems that if cultural characteristics are significantly associated with police-reported crime rates, they tend to decrease them. The higher the proportion of recent immigrants in a neighbourhood, the lower the rates of drug offences, all types of violent crime, mischief and other thefts. These results are in line with those of most international studies (Martinez 2006).

Thus, all else being equal, high-immigration neighbourhoods generally have lower crime rates. Excluding other thefts, the types of crimes that are strongly linked to recent immigration are also associated with access to socio-economic resources. Thus, the relationship between recent immigration and crime seems to complement the link mentioned above between access to socio-economic resources and crime.

In other words, given two neighbourhoods where residents have comparable access to socio-economic resources, the one with a higher proportion of recent immigrants is likely to have a lower crime rate (Table 10). When socio-economic resources are not taken into account, neighbourhoods with a proportion of recent immigrants that is higher than the city's average have a slightly higher violent crime rate (6.65) than other neighbourhoods (6.31). This difference, however, is small, if we compare it with the gap between neighbourhoods whose residents have a higher than average access to socio-economic resources (4.87) and other neighbourhoods (8.19). However, when the comparison is made between neighbourhoods where residents have similar access to socio-economic resources, high-immigration neighbourhoods have lower violent crime rates than other neighbourhoods.

Table 10
Violent crime rates (per 1,000 residents and workers), by immigration and access to socio-economic resources, city of Toronto neighbourhoods, 2006

	Recent immigrants		Total
	Lower than average proportion	Higher than average proportion	
	rate		
Access to socio-economic resources			
Lower than average access	8.54	8.01	8.19
Higher than average access	5.07	4.56	4.87
Total	6.31	6.65	6.51

Note(s): Population at risk includes residents and workers.
Source(s): Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Many theories can explain why neighbourhoods with higher proportions of recent immigrants have lower crime rates.

The average income of recent immigrants in the city of Toronto ($24,679) is considerably lower than that of other residents ($48,141). This financial situation causes many of them to live in neighbourhoods where access to socio-economic resources is limited and violent crime rates are high. Despite their lower incomes, more recent immigrants in the city of Toronto hold a university degree (56%) than other residents (45%), which is also true for Canada as a whole (Galarneau and Morissette 2008). This high level of education is in contrast to that of many other residents of those neighbourhoods.

Thus, the level of education of recent immigrants seems to have a protective effect on crime in neighbourhoods that are disadvantaged from a socio-economic point of view. Moreover, some authors have theorized that the arrival of immigrants in certain disadvantaged neighbourhoods might encourage the development of new forms of social organization and community revitalization (Martinez 2006).

Neighbourhood ethno-cultural diversity is associated with rates of three types of crimes only (at lower significance thresholds): sexual assault, other thefts and drug offences.

Demographic characteristics of neighbourhood residents

In comparison with socio-economic and cultural characteristics, demographic characteristics of residents are only slightly associated with crime in Toronto's neighbourhoods.

Rates for most types of crime are lower where there are higher proportions of elderly people. These associations perhaps reflect the fact that most people aged 65 and older are more likely to be home at any given time of day, and thus informally watch over the neighbourhood. As for the proportions of children under 15 and of young men aged 20 to 29 who live in the neighbourhood, they are associated with motor vehicle theft, common assault and harassment rates.

Urban characteristics of neighbourhoods

The spatial organization of several types of police-reported crime is linked to urban characteristics. In general, the results show that violent crime rates are more closely associated with urbanization, while property crime rates are more related to centrality. In fact, urban neighbourhoods (dense neighbourhoods with renter residents who move often) show high rates of all types of violent offences, with the exception of robberies. Central neighbourhoods (those close to downtown with old buildings) show high rates of mischief, breaking and entering and theft from a motor vehicle. Drug offence rates are associated with both urbanization and centrality.

Although they coincide in most medium-size cities, centrality and urbanization show different spatial configurations in Toronto. By examining them separately, the complex relationships between crime and neighbourhood characteristics can be better understood.

Central neighbourhoods are the most accessible of the entire city. Many transportation routes converge there, particularly public transit routes. Because of this accessibility, central areas are important centers of commerce. The downtown area is characterized both by its commercial activities and its financial district. Thousands of workers, students, consumers and tourists pass through there. Central neighbourhoods are therefore accessible and familiar, points of reference that many residents of the urban area know well. Building age is associated with distance to downtown since city growth occurs concentrically with new dwellings being built ever further from the historic center.

Some research suggests that accessibility brings together numerous crime opportunities, potential victims and properties that may be at risk of theft or damage. Because they are relatively accessible to the residents of the urban area (including perpetrators of crime), central neighbourhoods are more likely to be the location of criminal activity (Bernasco and Luykx 2003). In addition, the familiarity of central neighbourhoods makes them more vulnerable to potential thieves, who have a better knowledge of the physical environment (including escape paths) and of the residents' and workers' routines (Bernasco and Luykx 2003).

Finally, since numerous people travel through central neighbourhoods every day, these areas provide an anonymous setting that might be favourable to crime. Residents of central neighbourhoods might know their immediate neighbours, but they will not recognize everyone that passes by. For example, the anonymity provided by the city-centre in Montréal makes many passers-by indifferent to victimisation incidents they could witness (Paquin 2006). The accessibility, familiarity and anonymity of central neighbourhoods may provide an environment favourable to mischief, breaking and entering, and theft from a vehicle.

Urban neighbourhoods provide an environment characterized by its density and its apartment buildings, and are inhabited by renters who may not reside at the same address for an extended period. Those conditions do not favour the development of cohesive local communities able to exert social control over behaviour, particularly criminal behaviour (Sampson and Morenoff 2004). Moreover, the high residential mobility and the fact of being renters may limit people's attachment to their places of residence and neighbourhoods (Pain 2000; Brown et al. 2004).

As an indirect measure of the state of degradation of a neighbourhood's physical environment, the proportion of dwellings requiring major repairs is associated with the rates of all types of violent offences (except sexual assaults), mischief, motor vehicle theft and other thefts. Degradation of the physical environment might give the impression of ambivalence and might reflect local community disorganization (Brown et al. 2004).

Mischief rates are also higher near subway and train stations, as are rates of sexual assault, motor vehicle theft and robbery. These results perhaps reflect the fact that subway and train stations are busy places where crimes might go unnoticed. Because subway and train stations are means of access to the public transit system, many transit users tend to park their cars in the vicinity, which can increase motor vehicle theft opportunities.

Economic activities of neighbourhoods

Neighbourhoods' economic activities are associated with several types of crimes but, overall, they are more closely related to property crimes. In fact, a strong statistical association between property crime rates and commercial activity was noted in many other Canadian cities (Savoie 2008b). That is the case with commercial activity, which is very strongly linked to shoplifting, other thefts and, to a lesser degree, breaking and entering and motor vehicle theft.

By definition, shoplifting offences are associated with high commercial activity. Among commercial clusters, those that are not located in manufacturing areas show higher crime rates. That finding might be related to differences in the nature of the commercial activity. For example, businesses located in manufacturing areas are of the big-box type, which might affect shoplifting rates.

The association between commercial activity and motor vehicle theft probably reflects the fact that, by attracting consumers, commercial activity concentrates many vehicles in parking lots, which sometimes favours motor vehicle theft. There are also sometimes large parking lots at subway or train stations and in clusters of manufacturing jobs.

Several other types of crimes are also related to business activity: robbery, drug offences and assault (common and major). These associations likely reflect the fact that commercial activities attract many people to the same place, thus providing numerous opportunities for crime. In some way, commercial activities create an environment of intense human activity, an anonymous and impersonal environment that offers certain similarities with centrality.

Finally, all other things being equal, the presence of bars is not associated with crime, with the exception of theft from a vehicle. Given the aggregated nature of the data, no direct link can be made between bar customers and those thefts. Nevertheless, this association perhaps has to do with a particular environment in neighbourhoods with many bars, an environment that might favour the perpetration of these types of crimes (Felson et al. 2008).

Adjacent neighbourhoods

Spatial regressions allow us to take certain information on the relationships between crime and neighbourhood characteristics into consideration. Mainly, spatial error and spatial lag variables account for territorial situations that cross over census tract boundaries. For example, crime observed in a census tract might be influenced by crime in adjacent census tracts or by their characteristics. More information on this technique is provided in "Spatial autocorrelation and regression" in the Methodology section.

Results show that shoplifting is not affected by adjacent neighbourhoods.[4] That result, which was also observed in Saskatoon (Charron 2008), probably reflects the fact that the location of shoplifting hot spots depends solely on the characteristics of business clusters and not on those of adjacent neighbourhoods.

Hot spots for other types of crimes are associated with adjacent neighbourhood characteristics. They cover several adjacent census tracts, and the characteristics of those neighbourhoods do not account for each of these spatial structures. These structures might reflect the fact that such crimes are committed by a small number of people who operate mainly in those hot spots. They are perhaps also associated with local crime cultures, in places where certain types of crime would be reported differently to the police.

3 Conclusion

The spatial analysis of crime in the city of Toronto illustrates the complex links between police-reported crime and neighbourhood characteristics. Results from this analysis have shown that certain neighbourhood characteristics are related to higher or lower crime rates.

Violent crime rates have been found to be more concentrated in neighbourhoods whose residents have a limited access to socioeconomic resources. Maps show that the spatial organization of violent crime rates (Map 5) closely matches residential organization based on income (Map 3). Violent crime rates are also higher in more "urban" neighbourhoods, i.e. neighbourhoods with higher population densities and higher residential mobility.

These results are consistent with previous research studies that have found that a lack of access to socio-economic resources and the "urban" character of neighbourhoods impede social control of crime by limiting social cohesion and sense of belonging (Forrest and Kearns 2001; Sampson et al. 2002; Pain 2000; Brown et al. 2004).

Property crime rates have been found to be associated with the economic activities of neighbourhoods: they are higher in areas with high commercial activity (such as shopping centres). Their rates are also generally higher in neighbourhoods that are close to the city centre.

Conversely, crime rates are generally lower in neighbourhoods with higher proportions of elderly residents and recent immigrants. Since Toronto has a large number of recent immigrants and will probably continue to attract immigrants (Bélanger and Caron-Malenfant 2005) and given the aging of the population, further studies are required to better understand the "protective" effect of the proportion of recent immigrants and elderly people on crime.

The analyses in this study compared police-reported crime statistics with neighbourhood characteristics for 2006. The analyses have shed light on the spatial correspondence between crime and neighbourhoods, but have not provided a description of the complex mechanisms underlying this spatial correspondence. For example, it is not known if reduced access to socio-economic resources in a specific neighbourhood precedes an increase in the crime

4 The Moran I score for shoplifting is not significantly different from 0. This result indicates that a census tract's (CT) shoplifting rate is not similar to those of adjacent CTs in the neighbourhood. Unlike shoplifting, sexual assault, harassment, breaking and entering and drug incidents are concentrated in adjacent CTs. On the other hand, the spatial structures of those incidents are explained by neighbourhood characteristics, which means that spatial regressions are not necessary for those types of crimes.

rate or if it is the increase in crime that leads residents with greater access to socio-economic resources to relocate to lower crime neighbourhoods.

To address such questions, it would be useful to analyse the data over a period of time. By evaluating both spatial correspondence and time synchronization, such analyses would allow us to better understand the complex mechanisms that are related to higher or lower crime rates across city neighbourhoods.

4 Methodology

4.1 Data sources

4.1.1 Incident-based Uniform Crime Reporting Survey

The Incident-based Uniform Crime Reporting Survey (UCR2) collects detailed information on individual criminal incidents reported to the police, including incident, accused and victim characteristics.

The UCR2 Survey allows a maximum of four offences per criminal incident to be recorded in the database. The selected offences are classified according to their level of seriousness, which is related to the maximum sentence that can be imposed under the *Criminal Code*.

The major offence categories (violent offences and property offences) are based on the most serious offence in each incident, as are the crime rates published annually by the Canadian Centre for Justice Statistics (CCJS). In this type of classification, a higher priority is given to violent offences than to property offences. As a result, less serious offences may be under-represented when only the most serious offence is considered.

When the analysis is on individual offence types, all incidents in which the offence is reported are included, whatever the seriousness or the ranking of the offence in the incident. In this study, this includes incidents of sexual assault, criminal harassment, uttering threats, assault (common and major), robbery, shoplifting, motor vehicle theft, theft from a motor vehicle, other thefts, breaking and entering, mischief and drug offences. This method provides a more complete spatial representation of the different types of individual offences.

This report includes most *Criminal Code* offences and all offences under the *Controlled Drug and Substances Act*, but it excludes offences under other federal and provincial statutes and municipal by-laws. Also excluded are *Criminal Code* offences for which there is either no expected pattern of spatial distribution or a lack of information about the actual location of the offence. For example, administrative offences, including bail violations, failure to appear and breaches of probation, are typically reported at court locations. Also, threatening or harassing phone calls are often reported at the receiving end of the call and impaired driving offences may be more likely to be related to the location of apprehension (for example, apprehensions resulting from roadside stop programs).

4.1.2 Census of Population

The Census of Population provides the population, dwelling and workplace counts not only for Canada as a whole, but also for each province and territory, and for smaller geographic units, such as cities or districts within cities. The census also provides information about Canada's demographic, social and economic characteristics.

The detailed socio-economic data used in this report are derived from the long form of the census, which is completed by a 20% sample of households. The Census of Population is conducted by Statistics Canada every five years, and was last carried out in 2006.

4.2 Geocoding

Geocoding is the process that is used to match a particular address with a geographic location on the earth's surface. In this report, an address corresponds to the location of an incident that was reported to the police, after aggregation to the block-face level— that is, to one side of a city block between two consecutive intersections. This is done by matching records in two databases, one containing a list of addresses, the other containing information about the

street network and the address range within a given block. The geocoding tool will match the address with its unique position in the street network. As the street network is geo-referenced (located in geographic space with reference to a co-ordinate system), it is possible to generate longitude and latitude values—or X and Y values—for each criminal incident. Where the incident location does not correspond to an address, geocoding is performed by creating a point on, say, an intersection of two streets or the middle of a public park. X and Y values in the criminal incident database provide the spatial components that allows points to be mapped, relative to the street or neighbourhood in which the incidents occurred.

For the purposes of this report, the Toronto Police Service sent to the CCJS the addresses of the incidents selected, reported and entered in the UCR2 database in 2006. This information was resolved by the CCJS into a set of geographical co-ordinates (X and Y) for each address. These co-ordinates were rolled up to the mid-point of a block-face in the case of specific addresses, and to intersection points in the case of streets and parks.

The Toronto Police Service provided information on 119,259 selected incidents for 2006. Through geocoding 106,175 of them (89%) were located. Some incidents could not be geocoded because they were linked to more than one address (6,739). The remaining incidents (6,345) either contained information that was too vague or were located outside the city of Toronto's boundaries.

The low percentage of incidents that failed geocoding did not create a bias in offence trends. In fact, geocoded offences and offences prior to geocoding both account for the same proportion of overall crime.

4.3 Mapping techniques

Kernel analysis is a method for representing the spatial distribution of crime data. This method makes it possible to examine criminal incident point data across neighbourhood boundaries and to identify areas where these incidents are concentrated. The goal of kernel analysis is to estimate, based on a point pattern, how the density of events varies across a study area. Kernel analysis produces a smooth map of density values.

In kernel estimation, a fine grid is overlaid on the study area. Distances are measured from the centre of a grid cell to each observation that falls within a predefined region of influence known as a bandwidth. Each observation contributes to the density value of that grid cell based on its distance from the centre of the cell. Nearby observations are given more weight in the density calculation than those that are farther away. The product of the kernel estimation method is a matrix (raster image) displaying local density values. In this study, the grid cell size is 100 square metres and the research radius used is 1,000 metres. This method of analysis was applied using the kernel density tool available in the ArcGIS Spatial Analyst extension.

Density matrices were produced for the different types of crimes examined in this study and for the population at risk (residential and working population in each census block). Crimes rates were produced by dividing, for each cell, the crime density value by the population at risk density value. For each type of offence, the categories were defined as follows: less than one third of the average rate; from one third to one half of the average rate; from one half to two thirds of the average rate; from two thirds of the average rate to 1.33 times the average rate; from 1.33 times the average rate to twice the average rate; from twice to three times the average rate; and more than three times the average rate.

4.4 Variables

Crime rate: For the purposes of this study, the crime rate represents the number of incidents per 1,000 residents and workers. Crime data are from the 2006 Incident-based Uniform Crime Reporting Survey, while data on the number of residents and workers are derived from the 2006 Census of Population. For each type of crime, all incidents that include at least one offence of that type are counted. For example, an incident that includes one mischief violation and one common assault violation will be counted in both the mischief rate and the assault rate. The property crime rate is the only exception. In that case, only incidents that include at least one property offence, but that do not include a violent offence are counted.

Neighbourhood characteristics: Data on neighbourhood characteristics are taken from the 2006 Census.

Access to socio-economic resources: See "Factor analysis" in the Methodology section.

Economic vulnerability: See "Factor analysis" in the Methodology section.

Visible minorities: Percentage of residents in a census tract who indicated they were members of a visible minority. Under the *Employment Equity Act*, members of visible minorities are "persons, other than aboriginal peoples, who are non-Caucasian in race or non-white in colour."

Recent immigrants: Percentage of residents in a census tract who immigrated to Canada between 1997 and 2006.

Ethno-cultural diversity:Value of the Shannon diversity index for visible minority groups in a census tract. The entropy index measures the diversity of the groups in a census tract as calculated using the following equation:

$$H_i = \sum_{i=1}^{S} p_i \ln(p_i)$$

where **i** is the census tract, **S** the number of visible minority groups (11, including the group of non-members of a visible minority group) and **pi** the proportion of the population represented by the group in the census tract. If all the groups are found in equal proportions in a census tract, the diversity index has a maximum value 2.39, since in this case, there are 11 groups. If one group is particularly dominant in terms of its number of members in the census tract, the value of the index will approach 0.

Visible minority groups were selected to measure ethno-cultural diversity since they are less numerous and more clearly defined than groups based on ethnic origin.

Children: Percentage of residents in a census tract who were under 15 years of age on Census Day.

Elderly people: Percentage of residents in a census tract who were 65 years and older on Census Day.

Young men: Percentage of male residents in a census tract aged 20 to 29 on Census Day. Crime statistics show that young men aged 15 to 24 are more likely to be victims of crime (Gannon and Mihorean 2005) or to be accused of criminal acts (see the "Neighbourhood characteristics" section of the report). However, the spatial distribution of young men aged 15 to 19 is very similar to that for children aged 15 and under, both groups being overrepresented in the same family-oriented and residential census tracts. An exploration of the data showed, however, that young men aged 20 to 29 had a particular spatial distribution that was associated with crime rates in a different way.

Centrality: See "Factor analysis" in the Methodology section.

Urbanization: See "Factor analysis" in the Methodology section.

Major repairs: Percentage of dwellings in a census tract that residents have identified as requiring major repairs. This includes, for example, the repair of defective plumbing or electrical wiring, or structural repairs to walls, floors or ceilings.

Commercial activity: Number of persons working in a census tract in industries designated by codes 44, 45 (Retail trade) and 72 (Accommodation and food services) in the 2007 North American Industry Classification System (NAICS).

Manufacturing jobs: Number of persons working in a census tract in industries designated by codes 31 to 33 (Manufacturing), and 48 and 49 (Transportation and Warehousing) in the 2007 NAICS.

Office jobs: Number of persons working in a census tract in industries designated by codes 51 (Information and Cultural Industries), 52 (Finance and Insurance), 53 (Real Estate and Rental and Leasing), 54 (Professional, Scientific and Technical Services), 55 (Management of Companies and Enterprises) and 56 (Administrative and Support, Waste Management and Remediation Services) in the 2007 NAICS.

Bars: Number of persons working in a census tract in businesses designated by sub-code 7224 (Drinking Places [Alcoholic Beverages]) in the 2007 NAICS.

4.4.1 Factor analysis

Factor analysis is used to reveal latent characteristics (i.e. those that are not measured directly) using variables with which they might be associated. With this method, variables that are strongly correlated contribute more to the definition of certain factors. These contributions make it possible to determine the importance of each factor in a census tract (see "Spatial analysis units" in the Methodology section) by calculating a factor score. The factor score becomes the neighbourhood characteristic that is used in a multivariate regression model.

In this study, factor analyses are used to define the main spatial structures contained in the socio-economic and urban characteristic variables. As previously mentioned, several census variables only partially and imperfectly account for the socio-economic and urban realities of neighbourhoods. Factor scores represent the major spatial trends common to the variables used in the factor analyses and are thus indicators of the various socio-economic and urban aspects of census tracts.

The factor analyses were produced using SPSS software. It was preferred over the principal components analysis in order to reveal latent factors (Costello and Osborne 2005). Since certain variables did not have normal distributions, the selected extraction method was that of the principal axis factors. Lastly, direct oblimin rotation was applied to clarify the factor structure while allowing the factors to be partially correlated, which corresponds more closely to the phenomena observed in the social sciences (Costello and Osborne 2005).

The purpose of the first factor analysis performed in this study was to identify the main spatial structures of socio-economic inequalities among neighbourhoods. Nine variables were included in the analysis: the average property value, the average income of residents,[5] the proportion of residents[6] with a university degree, the proportion of residents who did not finish high school, the proportion of part-time workers, the proportion of total income from government transfers, the unemployment rate, the proportion of residents in single-parent families, and the proportion of residents in low-income households.

The results show two major attributes (Table 11). Access to socio-economic resources distinguishes census tracts based on their property values, the average employment income of their residents, the proportion of total income from government transfers, the proportion of single-parent families and the proportion of low-income households but, particularly, based on their residents' level of education. Economic vulnerability distinguishes census tracts mainly based on the proportion of low-income households and on unemployment rates.

5 Residents aged 15 and older who earn an income (after-tax income).
6 Residents aged 15 and older who are not full-time students.

Table 11
Matrix of contribution to socio-economic factors, city of Toronto, 2006

	Access to socio-economic resources	Economic vulnerability
	percent	
Percent of variance explained	56.3	15.5
	contribution to factor	
Average property value	0.717	-0.368
Average employment income	0.724	-0.319
University graduates	0.904	0.081
No high school diploma	-0.858	0.036
Part-time workers	-0.029	0.289
Government transfers	-0.898	0.474
Unemployment rate	-0.412	0.734
Single-parent families	-0.748	0.450
Low-income households	-0.691	0.794

Source(s): Statistics Canada, 2006 Census.

The goal of the second factor analysis was to show the main urban differences among neighbourhoods. Ten variables were included in the analysis: the average number of rooms per dwelling, the proportion of single-detached houses, the proportion of apartment buildings, the residential density, the proportion of residents who moved in the previous year, the proportion of residents who did not change their address in the previous five years, the proportion of residents who drive to work, the distance to downtown and the average building age.[7] The proportion of dwellings requiring repairs was not used in the analysis because its link to crime night be considered of a different order (Kelling and Coles 1998) and thus it is more advisable to keep it as an independent variable.

The results show two major dimensions (Table 12). Urbanization distinguishes census tracts by the number of rooms per dwelling, the proportion of renters, dwelling type, density, residential mobility and driving to work. Centrality distinguishes census tracts mainly based on distance to downtown and on building age.

7 Building age was determined based on the age categories used in the census. For example, buildings constructed between 1961 and 1971 were given the age of 40 (2006 – 1966).

Table 12
Matrix of contribution to urban factors, city of Toronto, 2006

	Urbanization	Centrality
	percent	
Percent of variance explained	58.6	17.8
	contribution to factor	
Rooms per dwelling	-0.942	-0.075
Renters	0.792	0.246
Single-detached houses	-0.878	-0.121
Apartment buildings	0.934	0.119
Residential population density	0.697	0.231
Residential mobility (1 year)	0.714	0.048
Residential stability (5 years)	-0.809	0.092
Commuting by car	-0.733	-0.576
Distance from downtown	-0.430	-0.772
Age of buildings	-0.109	0.831

Source(s): Statistics Canada, 2006 Census.

4.4.2 Coefficients of correlation for independent variables

Several pairs of independent variables show significant coefficients of correlation (Table 12). This finding confirms the fact that the neighbourhood characteristics suspected of being associated with crime are also interrelated. It also shows that cities are complex organisms, within which many factors interact with each other.

For example, the associations among socio-economic variables and ethno-cultural variables indicate that recent immigrants and visible minorities tend to live in socio-economically disadvantaged census tracts. Also, the coefficients in Table 13 indicate that young men are overrepresented in downtown neighbourhoods while children and the elderly are overrepresented on the outskirts.

Table 13
Pearson's correlation coefficient of neighbourhood characteristics, city of Toronto, 2006

	Number of the variable	1	2	3	4	5	6	7	8
Access to socio-economic resources	1	...	...	...	...	...	...	...	...
Economic vulnerability	2	-0.292**	...	...	...	...	...	...	...
Visible minorities	3	-0.591**	0.627**	...	...	...	...	...	...
Recent immigrants	4	-0.411**	0.745**	0.763**	...	...	...	...	...
Ethno-cultural diversity	5	-0.473**	0.344**	0.618**	0.454**	...	...	...	...
Children	6	-0.386**	0.397**	0.345**	0.288**	0.205**	...	...	...
Elderly people	7	0.024	-0.324**	-0.240**	-0.247**	-0.078	-0.334**	...	...
Young men	8	-0.072	0.191**	0.324**	0.282**	0.149**	-0.322**	-0.349**	...
Centrality	9	0.249**	-0.230**	-0.577**	-0.485**	-0.374**	-0.264**	-0.040	0.027
Urbanization	10	-0.088*	0.467**	0.223**	0.457**	0.094*	-0.235**	-0.344**	0.397**
Major repairs	11	-0.350**	0.300**	0.015	0.079	0.016	0.196**	-0.261**	0.119**
Subway or train station	12	0.349**	-0.059	-0.216**	-0.130**	-0.152**	-0.268**	-0.037	0.128**
Commercial activity	13	0.235**	-0.137**	-0.137**	-0.109*	-0.102*	-0.267**	-0.007	0.141**
Manufacturing jobs	14	-0.030	-0.107*	0.023	0.005	0.020	-0.126**	-0.029	0.088*
Office jobs	15	0.462**	-0.115**	-0.180**	-0.057	-0.138**	-0.394**	-0.023	0.170**
Bars	16	0.197**	-0.146**	-0.167**	-0.184**	-0.140**	-0.325**	-0.116**	0.282**

See notes at the end of the table.

Table 13 – continued

Pearson's correlation coefficient of neighbourhood characteristics, city of Toronto, 2006

	Number of the variable	9	10	11	12	13	14	15	16
Access to socio-economic resources	1	...	...	...	...	...	...	...	...
Economic vulnerability	2	...	...	...	...	...	...	...	...
Visible minorities	3	...	...	...	...	...	...	...	...
Recent immigrants	4	...	...	...	...	...	...	...	...
Ethno-cultural diversity	5	...	...	...	...	...	...	...	...
Children	6	...	...	...	...	...	...	...	...
Elderly people	7	...	...	...	...	...	...	...	...
Young men	8	...	...	...	...	...	...	...	...
Centrality	9	...	...	...	...	...	...	...	...
Urbanization	10	0.170**	...	...	...	...	...	...	...
Major repairs	11	0.480**	0.274**	...	...	...	...	...	...
Subway or train station	12	0.227**	0.231**	-0.078	...	...	...	...	...
Commercial activity	13	0.128**	0.161**	-0.146**	0.282**	...	...	...	...
Manufacturing jobs	14	-0.091*	0.099*	-0.165**	0.172**	0.617**	...	...	...
Office jobs	15	0.034	0.242**	-0.295**	0.373**	0.743**	0.615**	...	...
Bars	16	0.264**	0.262**	-0.046	0.266**	0.494**	0.298**	0.467**	...

* Significantly associated with dependent variable $p<0.05$
** Significantly associated with dependent variable $p<0.01$
*** Significantly associated with dependent variable $p<0.001$
Source(s): Statistics Canada, 2006 Census.

The significant correlations noted among the independent variables raise certain considerations of a technical nature. When correlations among independent variables are large (i.e. if there is multicollinearity), regression model results can be misleading. In this study, 15 variables were selected since it could be expected that the phenomena they represent have specific relationships with crime. Strongly correlated variables representing the same theoretical relationship with crime were grouped together by the factor analyses described above.

However, the proportion of visible minorities was excluded from the analysis because it was too strongly correlated with economic characteristics and other cultural characteristics of neighbourhood residents. In the regression models in this paper, all independent variables had variance inflation factors lower than 5, which means that collinearity is not a very significant issue in this data set.

4.5 Multivariate regressions

The backward method was used to determine the variables included in the models. The small number of incidents for some types of offences (such as sexual assault, criminal harassment and drug offences) could have caused some problems because of the large number of observations with a null rate. However, since the residuals from these models had a near-normal distribution, this had no effect on the models.

4.5.1 Spatial analysis units

Ecological studies like those conducted in crime cartography projects require enough geographic units or neighbourhoods to effectively and reliably model data. In previous studies, neighbourhoods as defined by local people (Winnipeg and Regina studies), census tracts (Montréal, Edmonton and Halifax studies) or dissemination areas (Thunder Bay and Saskatoon studies) were used in the examination of geographical units.

For the multivariate analyses in Section 2.3, census tracts (CTs) from the 2006 Census were used. Census tracts are small and relatively stable areas usually having a population of 2,500 to 8,000. CT boundaries must meet many delimitation criteria designed to maximize their use. For example, CT boundaries must be consistent with census subdivision boundaries; they should as far as possible follow permanent and easily recognizable physical features; and they should be as homogeneous as possible in terms of socio-economic characteristics, that is, have similar

economic status and living conditions at the time of their creation. Only 524 of the 531 Toronto CTs were included in the analyses because the remaining seven did not have a large enough population.

Most incidents were assigned to one CT based on their location. Other incidents, located on the border between two or more CTs, were assigned to all the CTs with which they shared a border. The number of incidents per CT is the sum of all incidents assigned to that CT. However, in order not to count incidents more than once, incidents assigned to more than one CT were downweighted. For example, an incident located at the border of four CTs was counted as 0.25 incidents for each of those four CTs.

4.5.2 Normalizing transformations

Ordinary least squares (OLS) regression is used to look at the distribution of the rates of certain types of incidents based on neighbourhood characteristics. Use of this method requires normally distributed continuous or quantitative variables. Since several of the variables examined in this analysis were not normally distributed, it was necessary to normalize the crime variables. Most of the variables or neighbourhood characteristics were also modified (using the natural logarithm or the square root) to give them a more normal distribution.

4.5.3 Standardization

Regression coefficients (or beta coefficients) show the expected variation, in standard deviation units, of the dependent variable per one standard deviation unit increase of the independent variable when all other variables are held constant. To allow comparisons among regression coefficients for a given model, all the variables were standardized, except for the presence of a train or subway station, whose only possible values are 0 and 1. The values thus vary from 1 (absolutely positive association) to –1 (absolutely negative association).

4.6 Spatial autocorrelation and regression (by Krista Collins)

Data measured over a two-dimensional study area, such as geocoded criminal incidents, are often affected by the properties of the location in which they reside. If adjacent observations are affected by the same location properties, the observations will not be independent of one another. This lack of independence must be accounted for in the data analysis to produce accurate and unbiased results. This is accomplished through spatial modelling of data and is important for any data set where there is a potential effect of location.

It is known that crime is not evenly distributed throughout cities and that it is concentrated in particular areas known as hot spots. This is an initial indication that there might be a location effect in crime data, which can be seen by examining a map of crime density in city neighbourhoods. There could be a positive effect where areas with high crime rates are surrounded by other areas with high crime rates, and areas with low crime rates are adjacent to other areas with low crime rates. A negative location effect results from areas of low crime being surrounded by areas with high crime and vice versa. Either scenario indicates some sort of spatial structure or spatial dependence in the data, signifying that neighbourhoods have an influence on each other. If the spatial structure of the data is not explained by the variables in the regression model, then there will be spatial effects in the model error terms. This phenomenon, which is known as spatial autocorrelation, violates the assumptions made in a standard regression analysis. The location effects must instead be accounted for in the multivariate model, to ensure accurate estimation of the regression coefficients and their associated variances.

For the purpose of spatial modelling, a definition of what constitutes neighbouring locations needs to be specified. In this analysis, a contiguity structure that includes all common borders or vertices that touch between the boundaries of the regions is used to define regions (census tracts in this document) as neighbours of each other. The neighbourhood structure defines which locations have a potential influence on each other, the neighbours, and rules out any potential influence of regions that are not considered to be neighbours. The neighbourhood structure is used to test for spatial autocorrelation and to specify the spatial component in the autoregressive spatial model.

The basic process of modelling spatial data is to first fit a standard least squares regression model to the data and then test the error terms for the presence of spatial autocorrelation. This is done by a statistical test called Moran's

I, which tests whether the error terms are randomly distributed over the study area. The value of the Moran's I statistic ranges from 1 to –1. A value approaching 1 indicates the presence of positive spatial autocorrelation, where regions with large error terms are adjacent to other areas with large error terms. A negative value near -1 indicates the presence of negative spatial autocorrelation, where regions with large error terms are neighbouring regions with small error terms. A value near zero indicates the absence of spatial autocorrelation. The significance of Moran's I statistic is determined by a random permutation approach, where a significant result indicates that there is spatial autocorrelation in the model error terms.

When spatial autocorrelation is detected in the residuals from a standard least squares regression model, a spatial model must be fit to the data instead. The spatial model provides the same analysis of the neighbourhood characteristics as the least squares model but adjusts for the spatial effects. This can be done in one of two ways: by adding an extra term to represent the effect of neighbouring locations or by modelling a spatial process in the error terms. In the former model, called the spatial lag model, a direct effect of the crime rate in neighbouring locations is assumed. In this case the average value from all neighbouring locations, termed the spatial lag, is added to the regression model to represent the direct effect of the neighbouring regions. The other model, termed the spatial error model, assumes the relationship between crime rates in adjacent neighbourhoods is the result of the same relationship of the explanatory variables in the adjacent neighbourhoods. Thus the spatial autocorrelation, detected in the standard regression model, is the result of spatially autocorrelated variables not present in the model. To determine the appropriate type of spatial model to use for any given data set, the data are empirically tested to determine the structure of the spatial dependency.

The results from a spatial regression analysis are essentially the same as those of other multivariate regression analyses. The regression coefficients represent the change in the crime rate for a unit change in the variable, when all other variables are held constant. Since the variables representing the neighbourhood characteristics are standardised, the size of their regression coefficients denote their relative contribution to the prediction of crime. The spatial lag and spatial error regression coefficients, however, cannot be explained in the same way. The spatial lag coefficient in part represents the effect of neighbouring locations but also accounts for some of the measurement error in using administrative units to define the neighbourhoods. Thus there is no direct interpretation of the spatial lag coefficient. Similarly, the spatial error coefficient represents a nuisance parameter in the model and has no direct interpretation. Rather, the spatial term is only retained in the model to make the other results accurate.

The overall fit of the spatial models is assessed by the squared correlation between the observed crime rate in each neighbourhood and the values predicted using the spatial model. This squared correlation is equivalent to the coefficient of determination (R^2), commonly used in standard regression models, where it represents the proportion of the variation explained by the regression model. However, in the presence of spatial autocorrelation the squared correlation between the observed and fitted values does not have the same interpretation. Rather, it represents the relative fit of the model. A value of 1 would represent a perfect fit of the model and values near zero indicate a poor predictive power of the model.

To ensure the spatial autocorrelation has been adequately accounted for in the model, the residuals from the spatial model are tested for the presence of spatial autocorrelation. This is done using Lagrange multiplier tests, which test for the presence of spatial error dependence in the spatial lag model and for a missing spatial lag variable in the spatial error model. If the statistical test is not significant, it indicates the spatial dependence in the data has been accounted for in the model.

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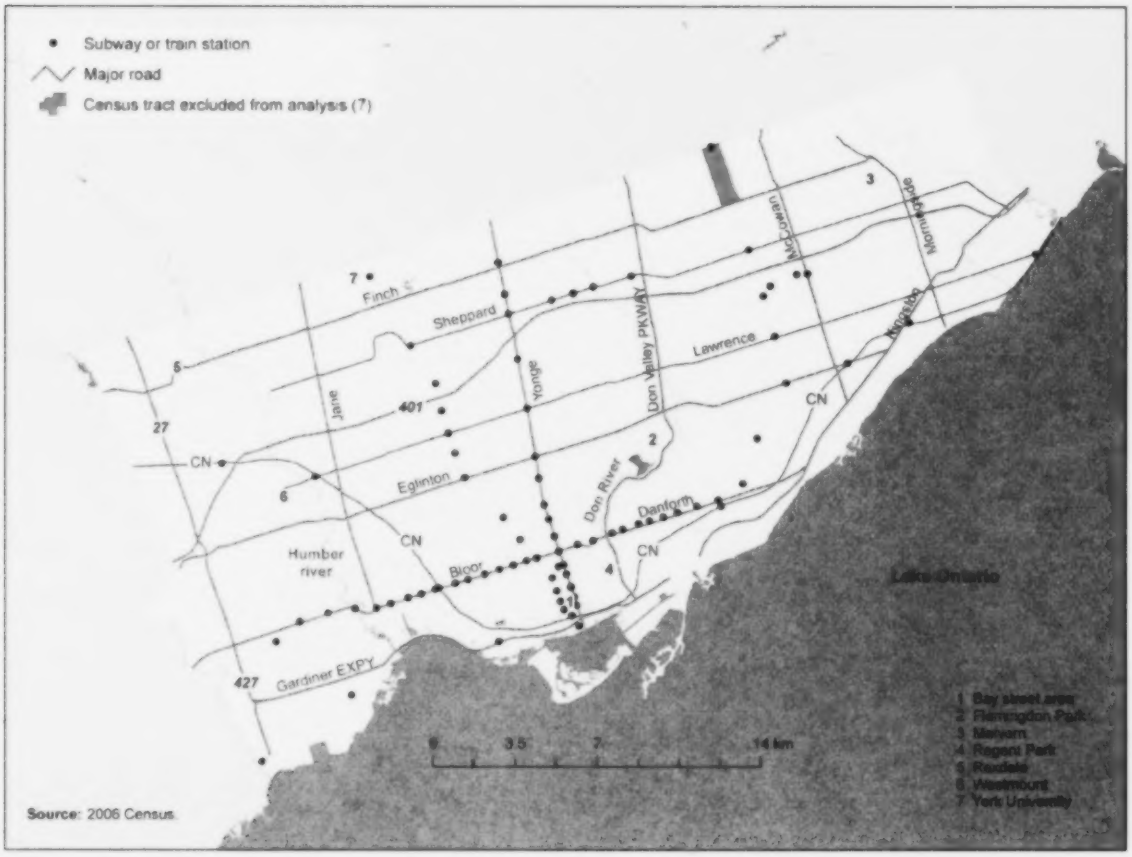
6 Appendix — Maps

Map 7
Local context, city of Toronto, 2006



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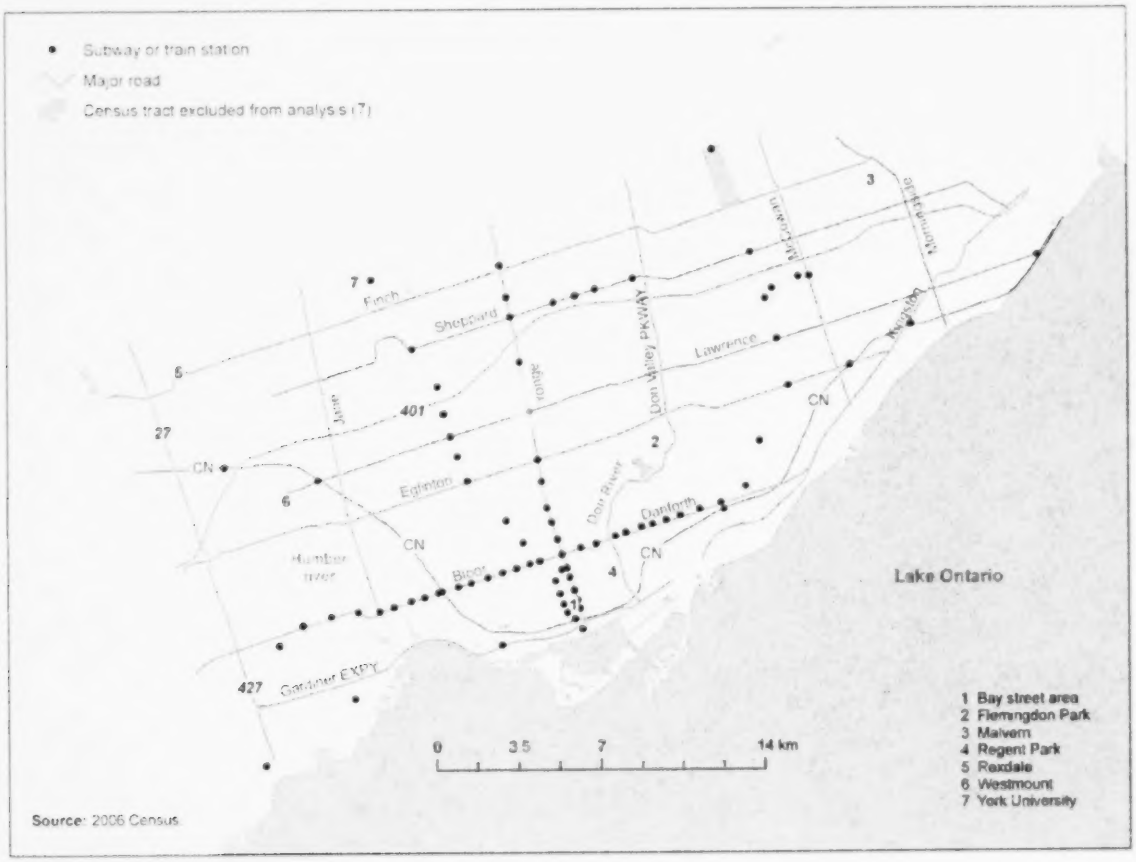
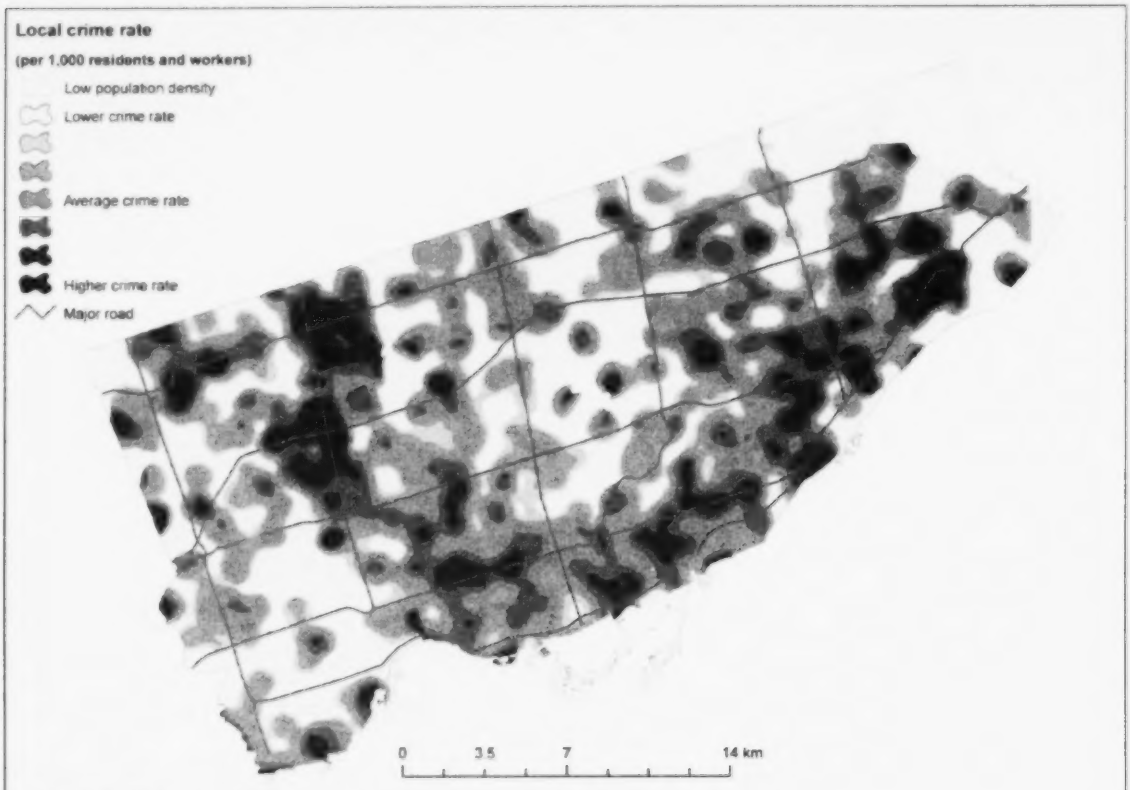


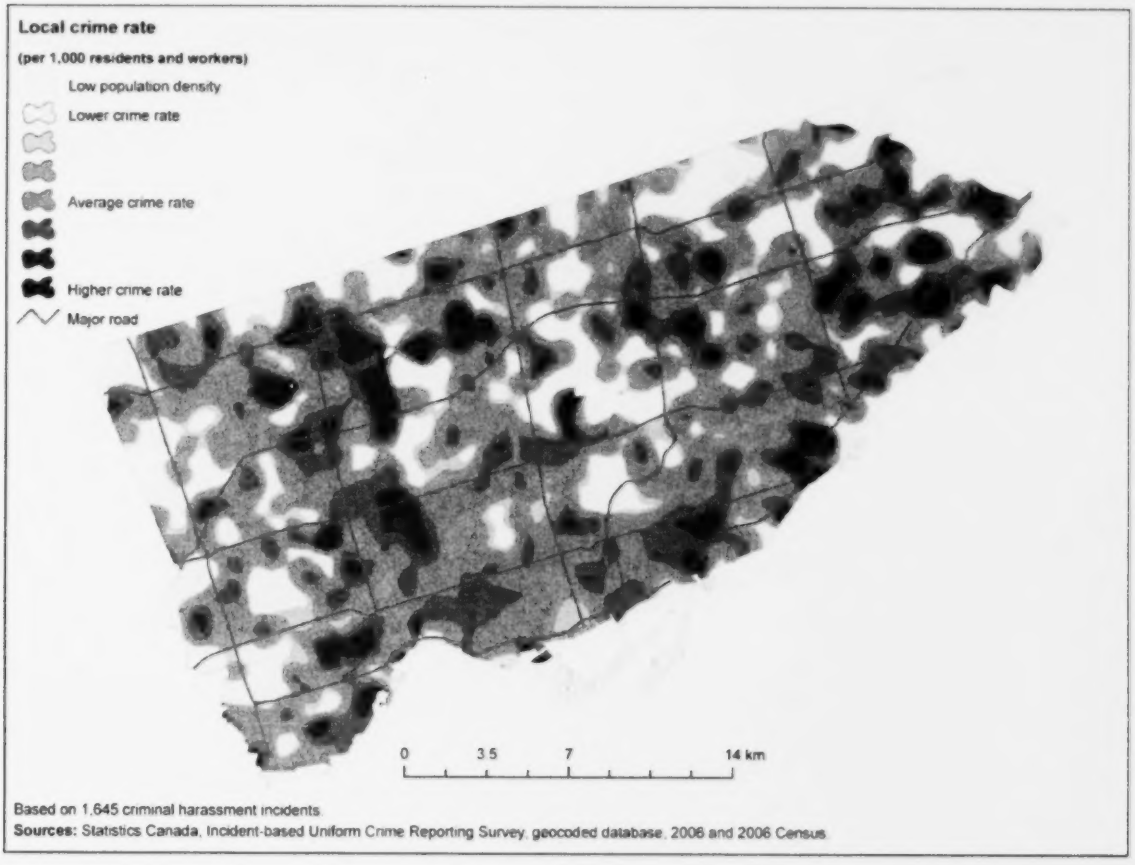
Source: 2006 Census.

Map 8
Local rates of sexual assault incidents, city of Toronto, 2006



Based on 1,137 sexual assault incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 9
Local rates of criminal harassment incidents, city of Toronto, 2006

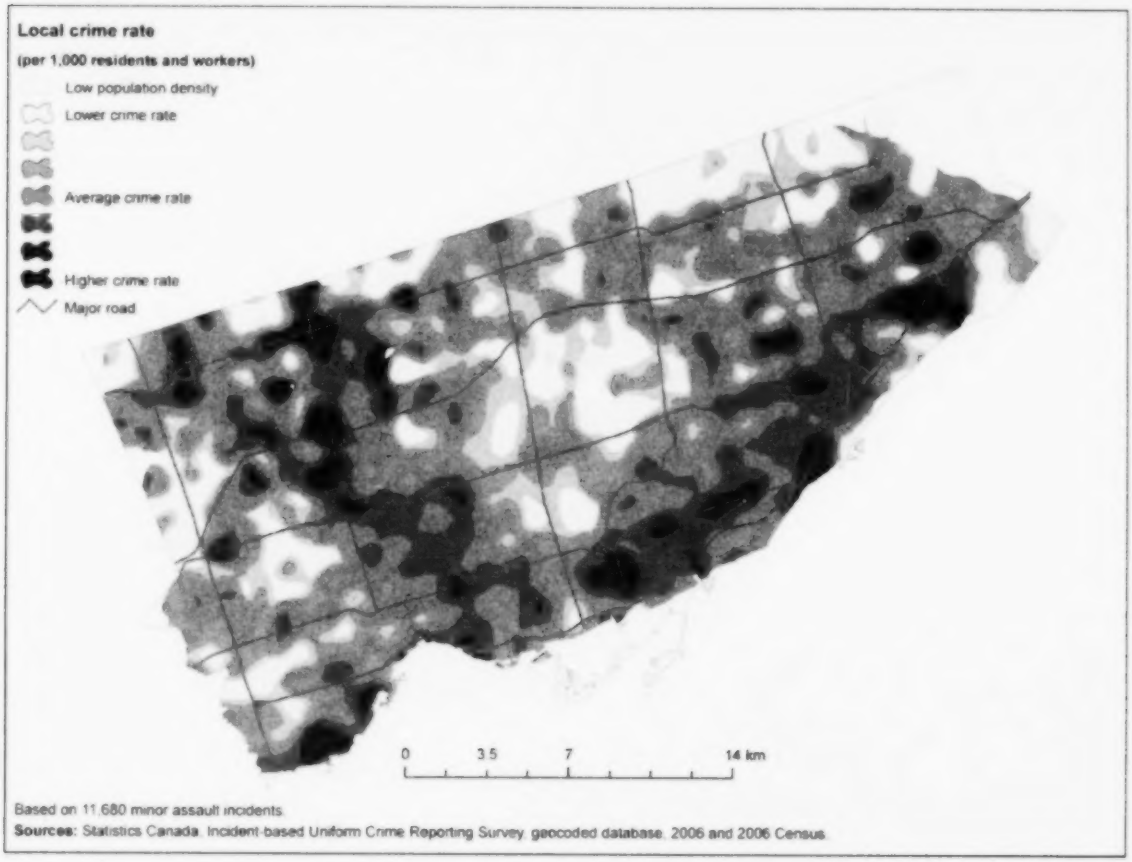


Based on 1,645 criminal harassment incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 10
Local rates of threat incidents, city of Toronto, 2006

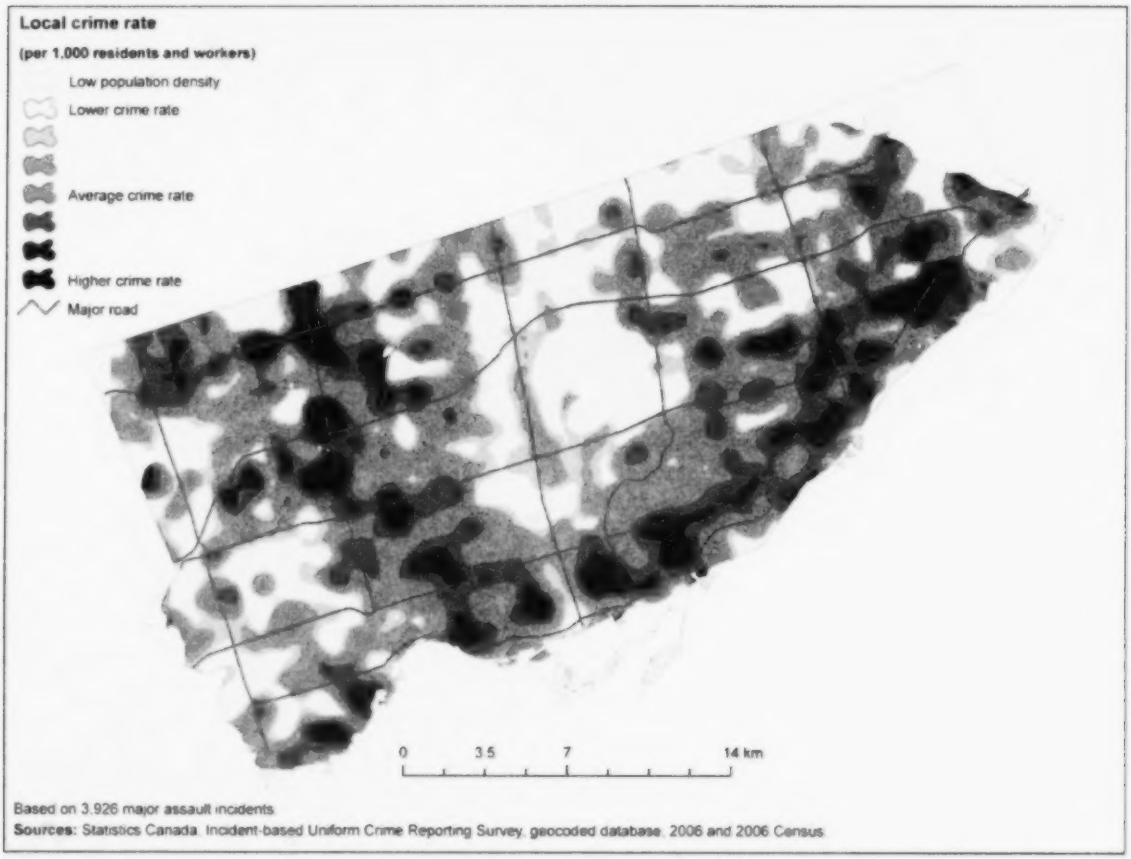
Based on 5,468 uttering threats incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 11
Local rates of minor assault incidents, city of Toronto, 2006



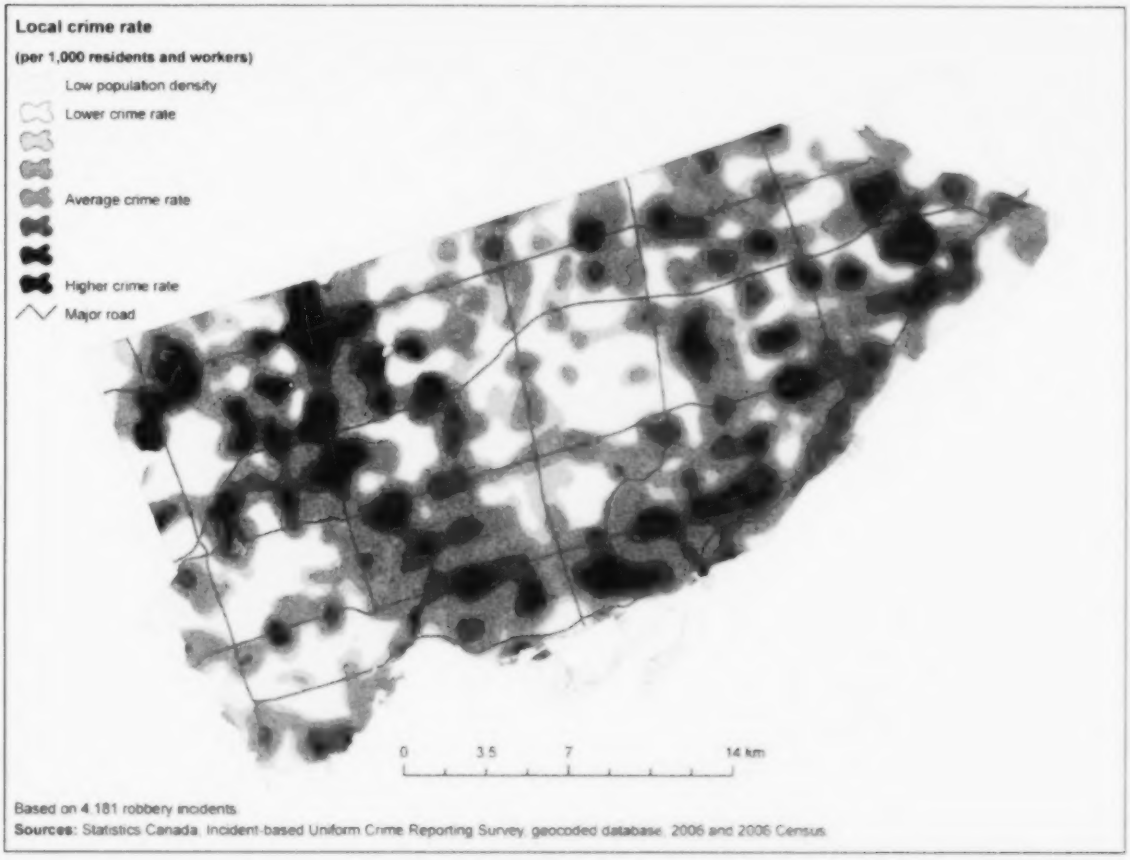
Based on 11,680 minor assault incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 12
Local rates of major assault incidents, city of Toronto, 2006



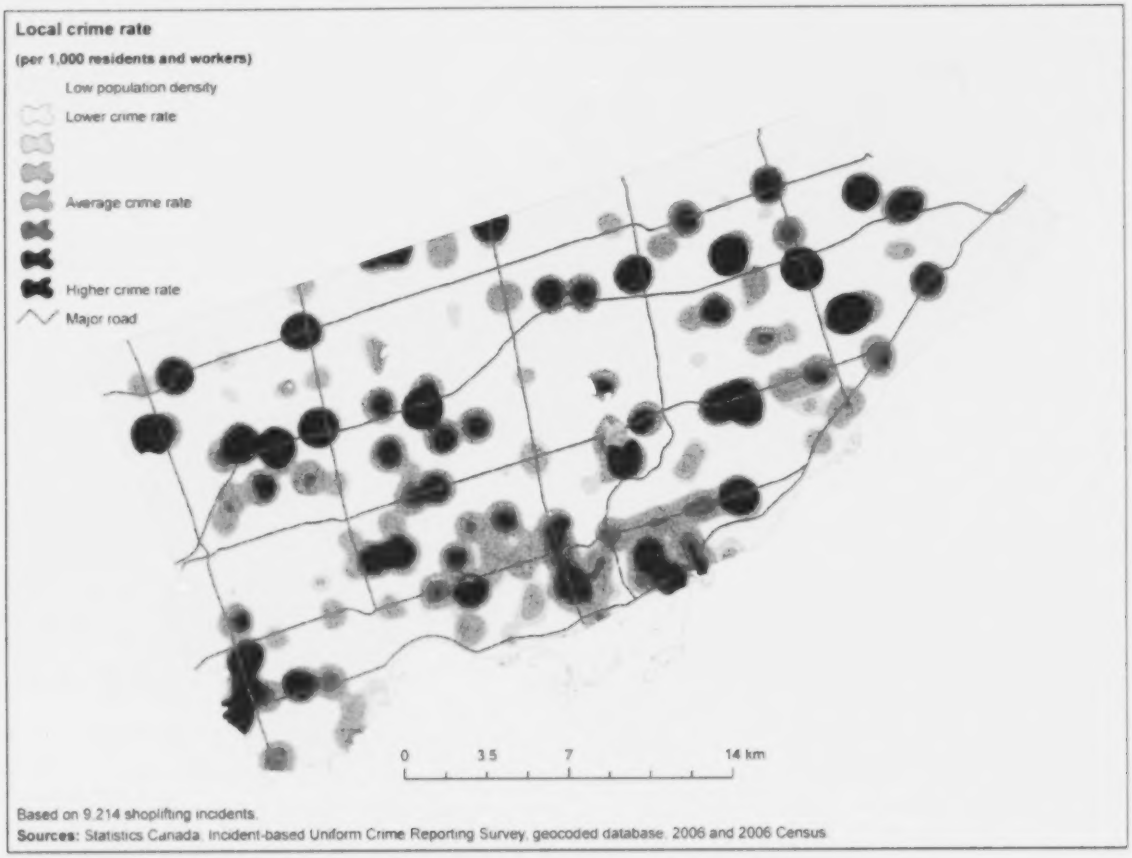
Based on 3,926 major assault incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 13
Local rates of robbery incidents, city of Toronto, 2006



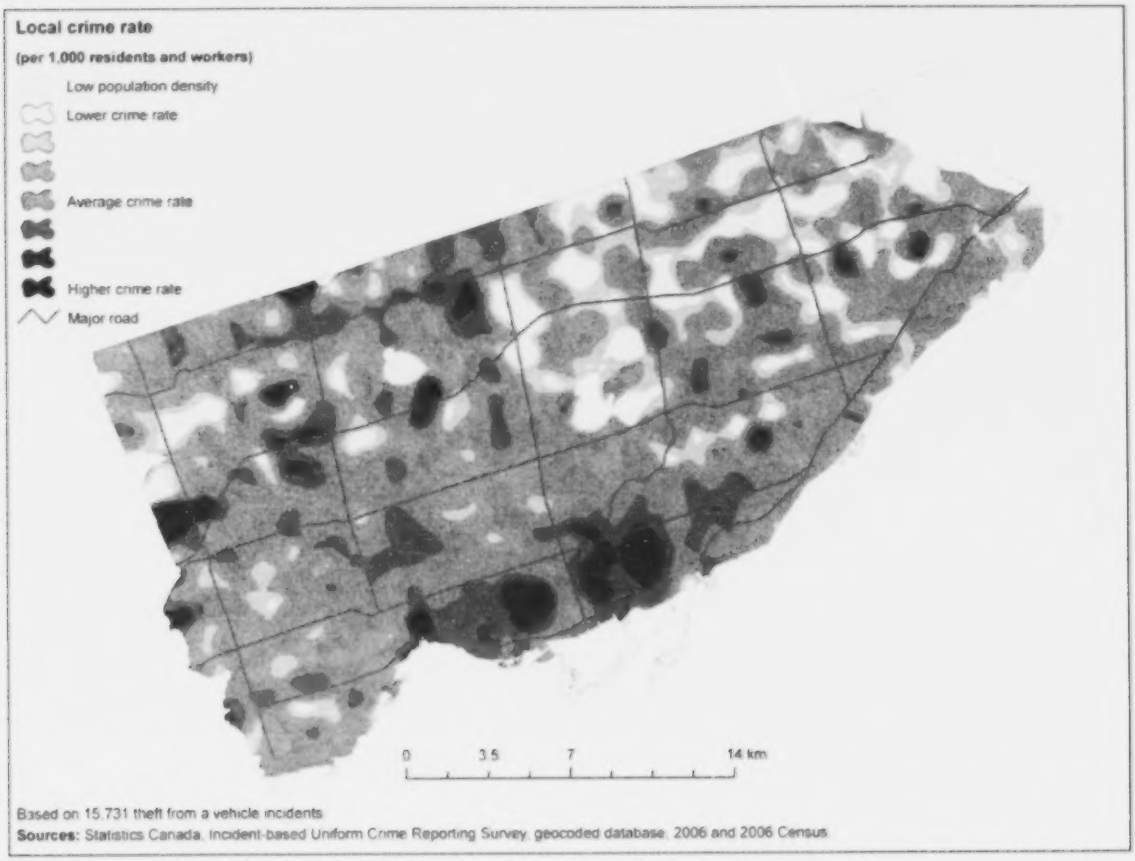
Based on 4,181 robbery incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 14
Local rates of shoplifting incidents, city of Toronto, 2006



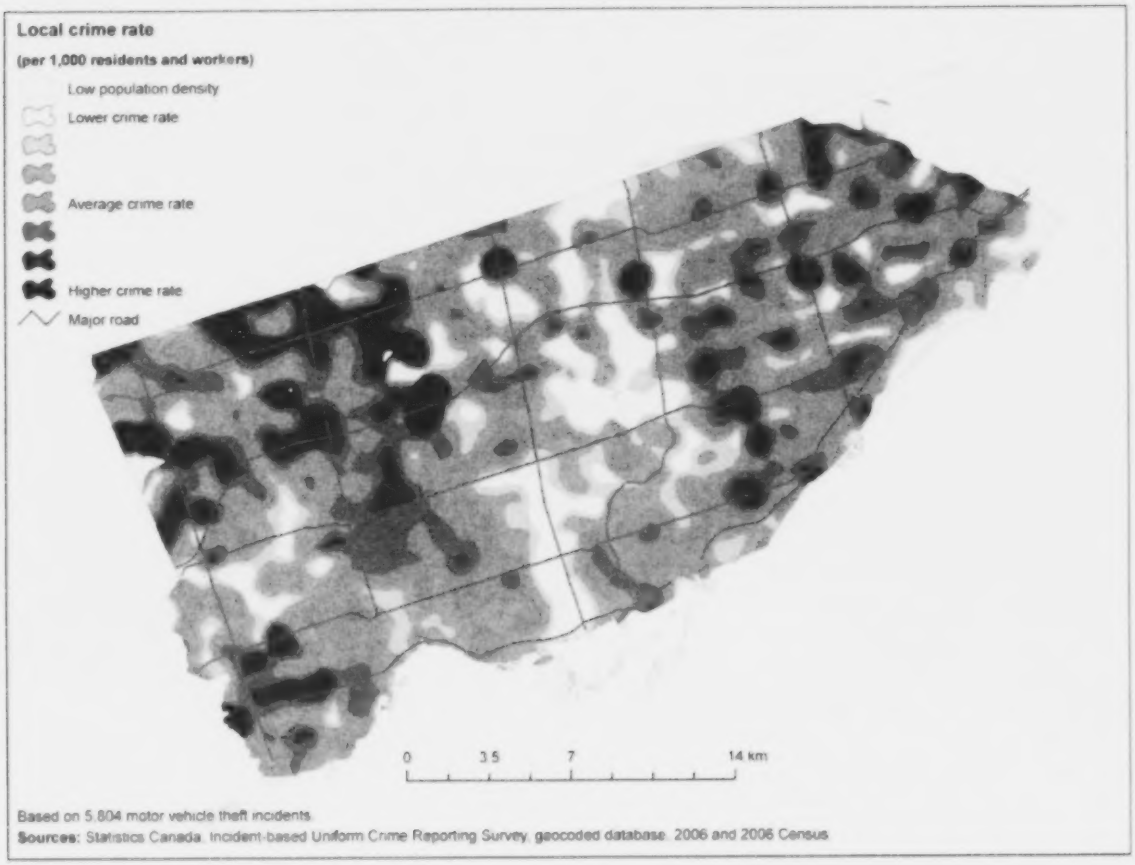
Based on 9,214 shoplifting incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 15
Local rates of theft from a motor vehicle incidents, city of Toronto, 2006



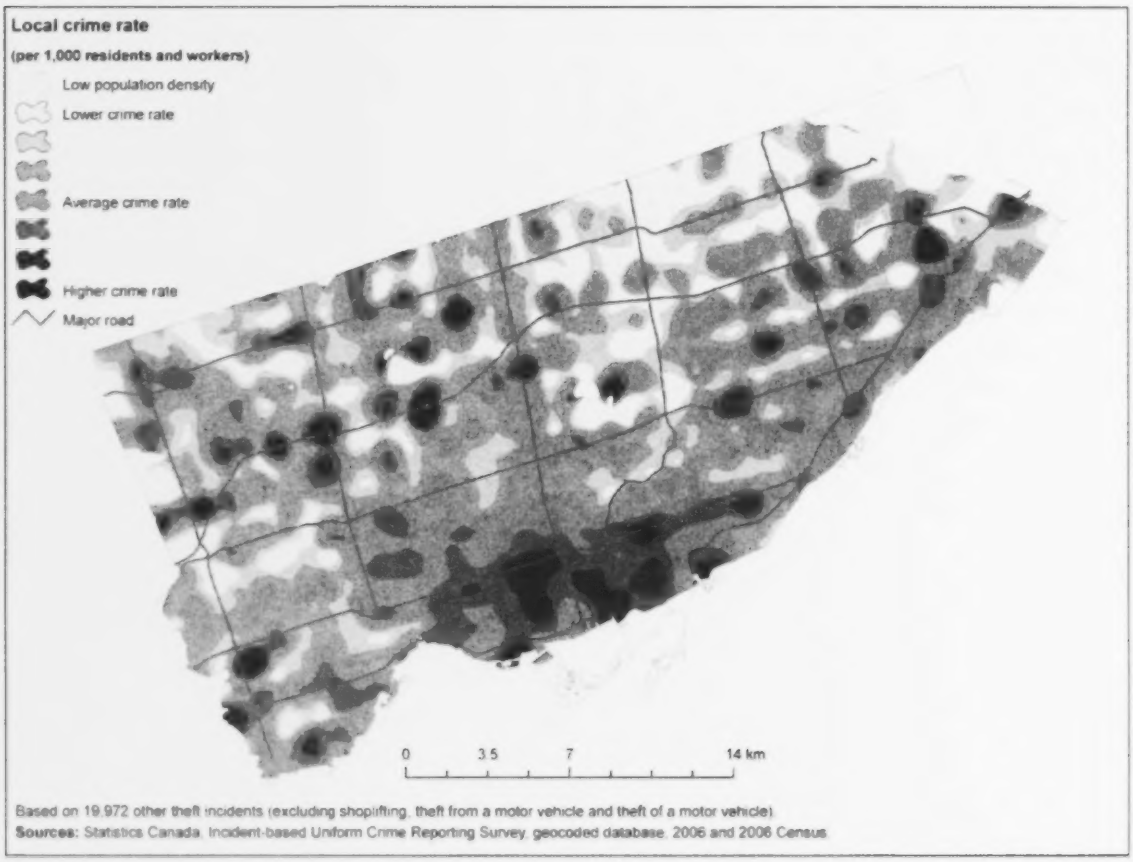
Based on 15,731 theft from a vehicle incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 16
Local rates of motor vehicle theft incidents, city of Toronto, 2006



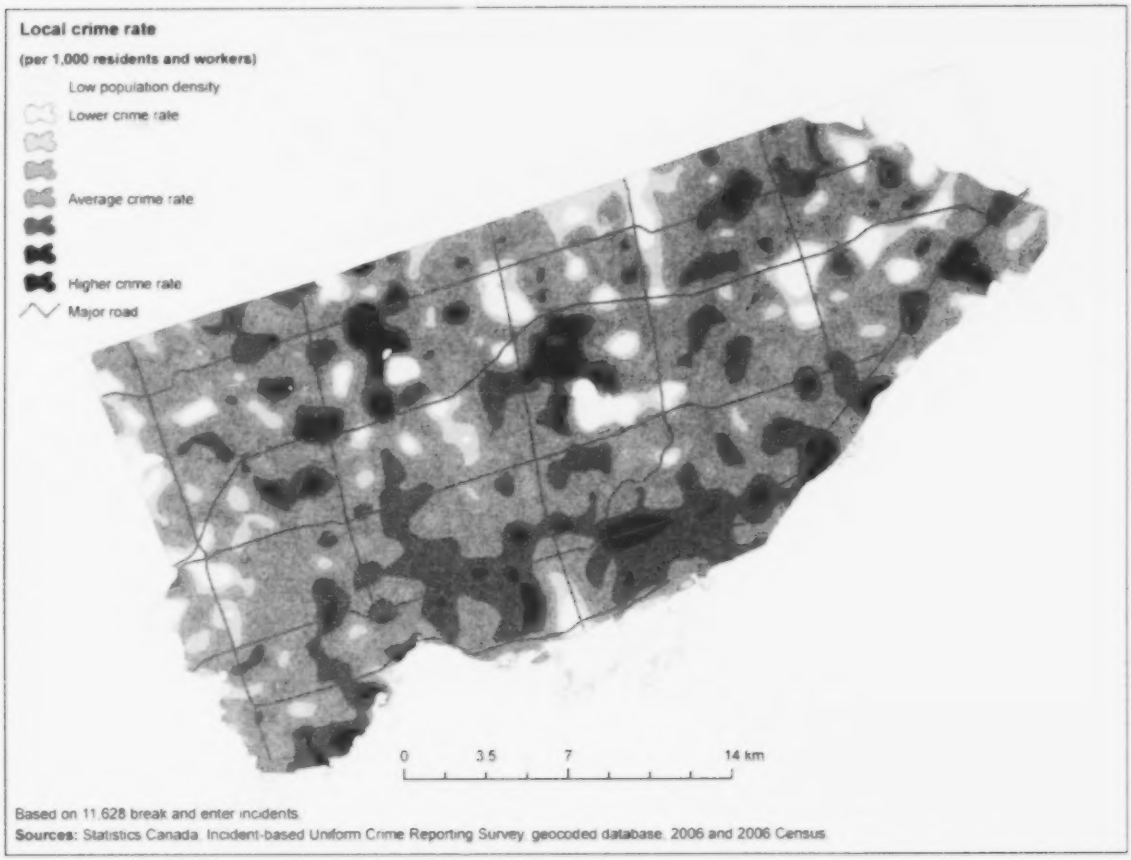
Based on 5,804 motor vehicle theft incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 17
Local rates of other theft incidents, city of Toronto, 2006



Based on 19,972 other theft incidents (excluding shoplifting, theft from a motor vehicle and theft of a motor vehicle).
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 18
Local rates of breaking and entering incidents, city of Toronto, 2006

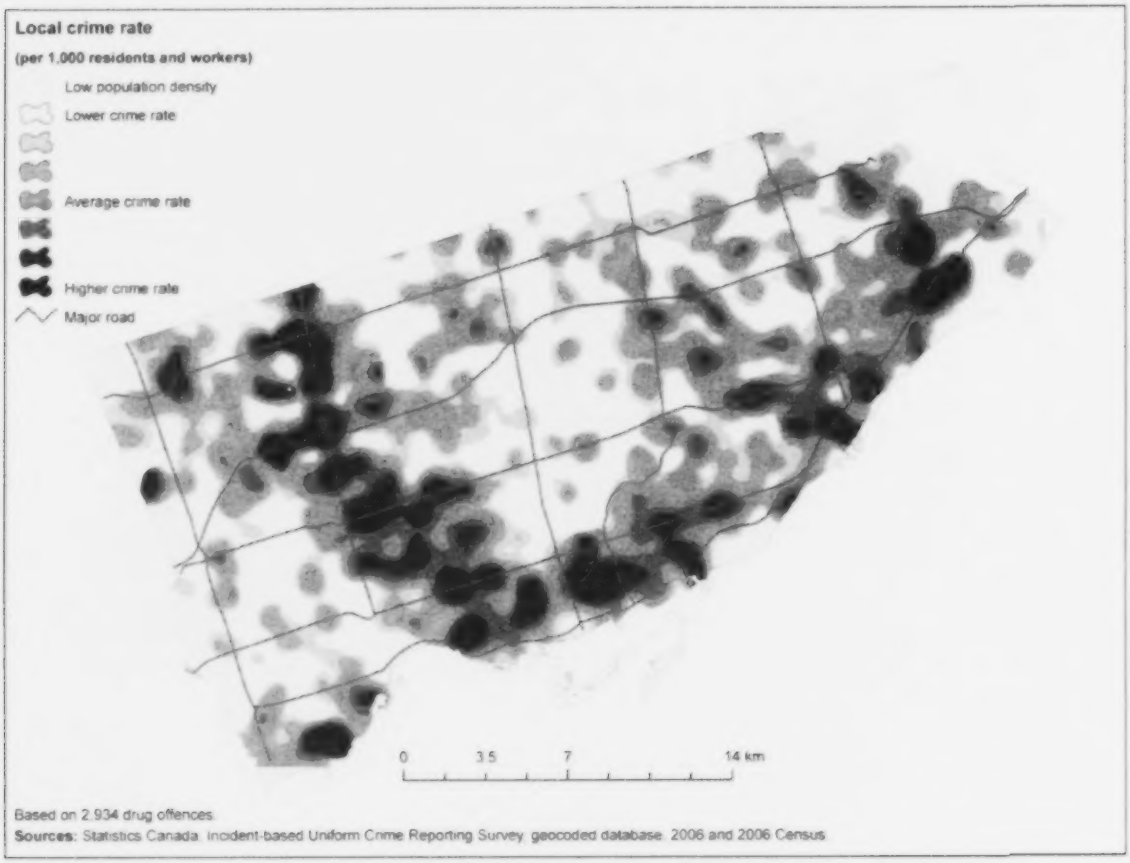


Based on 11,628 break and enter incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 19
Local rates of mischief incidents, city of Toronto, 2006

Based on 14,389 mischief incidents.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey, geocoded database, 2006 and 2006 Census.

Map 20
Local rates of drug offences, city of Toronto, 2006



Based on 2,934 drug offences.
Sources: Statistics Canada, Incident-based Uniform Crime Reporting Survey geocoded database, 2006 and 2006 Census.